The Information Economy: The Implications of Unbalanced Growth

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The Information Economy:
The Implications
# of Unbalanced Growth

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by

Lars Osberg

Edward N. Wolff

and

William J. Baumol

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Foreword

The early insights which identified the transition to an information society as perhaps Canada's greatest contemporary public policy challenge also generated a great many colourful clichés and sweeping generalities. Careful analysis and concrete evidence have been considerably more scarce.

The present book by Osberg, Wolff and Baumol is something of an exception. It examines in detail one aspect of the shift to a service economy made possible in large measure by the integration of computing and communications technologies. In particular, these authors explore the increasing importance of information services and "knowledge workers" in contemporary production patterns. Employing a classification of the labour force by occupation rather than by industry, they are better able to identify workers involved in information services, and to distinguish "data workers" engaged in routine data manipulation from "knowledge workers" creating new intellectual products or undertaking original analyses. On this empirical foundation it is possible to investigate concerns as to increasing income inequality or the "disappearing middle" associated with the information revolution. It is possible to explore the significance of education as a characteristic in determining incomes in various occupations. It is possible also to explore changes in productivity, education, technology, and labour force composition together as factors in the level and distribution of earnings. While the results set out in this volume are not definitive, they point the way toward, and provide a basis for, further more detailed and up-to-date explorations of these key questions.

And they do demonstrate that fears that the shift to an information society will lead to relatively fewer middle income jobs and relatively more low income jobs have not—at least this far—been realized; that post secondary education is reflected in higher incomes, at least for information workers; and that the growth of knowledge workers is accounted for—at least in the U.S.—not so much by a shift of demand towards information-intensive products as by a shift of production techniques within industries towards knowledge-based occupations.

This Institute's research program over the last few years has emphasized the transition to a service economy and the broader transformation to an information society. Work has been undertaken on trade in computer and communications products, the service sector, intellectual property rights, the spatial implications of the information economy (particularly in a Canadian regional development context), organizational and institutional change and adaptation, the telecommunications industry, the education sector, and so on. In all of these studies, the Institute's interest has been to document and assess the impact and implications of the economic and social changes resulting from the transformation to an information society and to explore the public policy options which present themselves from the analysis.

The present book is the latest in this series of IRPP studies of the information society. The combination of U.S. and Canadian-based analysis which it offers reflects the global character of the information revolution. Canada's ability to deal with the challenges it poses depends not only on understanding our own situation but also the general features of the structural changes in train more generally, perhaps especially in the United States.

The Institute is pleased to be able to publish this study. The book should both inform and stimulate the consideration of some pressing labour market issues as well as the wider policy agenda of the information economy.

A.R. Dobell
President

March 1989

Avant-propos

Les premiers indices annonçant que la transition vers une société de l'information risquait d'être le plus grand défi contemporain en matière de politique générale auquel le Canada ait jamais eu à faire face ont également donné le jour à une grande variété de clichés pittoresques et à des généralisations par trop absolues. Les analyses soigneuses et les preuves concrètes ont été beaucoup plus rares.

Le présent volume par Osberg, Wolff et Baumol est une exception. Il présente un examen détaillé d'un des aspects du changement vers une économie de service, changement rendu possible, en grande partie, grâce à l'intégration des technologies de l'informatique et de la communication. Ces auteurs explorent tout particulièrement l'importance grandissante des services de l'information et celle des "concepteurs" dans les structures de production contemporaines. À partir d'une classification des effectifs de travail par emploi plutôt que par industrie, ils ont été plus à même d'identifier les employés dont le travail se rapporte aux services de l'information et de faire la distinction entre les "applicateurs", qui mettent les données en pratique de façon routinière, et les "concepteurs", qui créent de nouveaux produits intellectuels ou qui entreprennent des analyses originales. Sur cette base empirique, il devient possible d'examiner les préoccupations relatives à l'augmentation des inégalités dans les salaires ou à la "disparition du revenu moyen" associées à la révolution de l'information. Il devient possible d'explorer la signification du niveau d'études comme facteur déterminant des salaires pour des emplois variés. Il devient également possible d'explorer l'ensemble des changements en matière de productivité, d'éducation, de technologie et de composition des effectifs de travail comme facteurs déterminants du niveau et de la répartition des salaires. Bien que les résultats présentés dans cet ouvrage ne soient pas définitifs, ils constituent une base de travail et ouvrent la voie à des études plus détaillées et plus à jour sur ces questions cruciales.

Ils prouvent également que ce que certains redoutaient, à savoir que le changement vers une société de l'information allait mener à une diminution des emplois à revenus moyens et à une augmentation des emplois à faibles revenus, ne s'est pas matérialisé, jusqu'à présent tout au moins; que les études postsecondaires mènent à des revenus plus élevés, dans le cas de ceux qui travaillent dans le secteur de l'information, pour le moins; et que l'augmentation du nombre des "concepteurs" ne s'explique pas tant par l'augmentation de la demande de produits informatisés spécialisés, aux États-Unis en tout cas, mais plutôt par un changement dans les techniques de production employées par les industries, en faveur d'emplois basés sur la conceptualisation.

Au cours de ces dernières années, le programme de recherche de l'Institut s'est particulièrement intéressé à la transition vers une économie de services et à la transformation plus vaste vers une société de l'information. Des travaux d'études ont été entrepris sur le commerce des produits de l'informatique et des communications, sur le secteur des services, sur les droits à la propriété intellectuelle, sur les implications spatiales de l'économie de l'information (en particulier dans le contexte du développement régional au Canada), sur les changements dans les organismes et les institutions et la manière dont ils s'adaptent, sur l'industrie des télécommunications, sur l'enseignement, etc. Dans le cadre de tous ces travaux, le but de l'Institut a été de documenter et de calculer les effets et les implications des changements économiques et sociaux qui résultent de cette transformation vers une société de l'information et d'explorer les options politiques qui s'imposent à la lumière de ces analyses.

Le présent ouvrage est le dernier en date de cette série d'études de l'IRP sur la société de l'information. La combinaison d'analyses américaines et canadiennes qui y sont présentées reflète le caractère global de la révolution de l'information. La capacité qu'aura le Canada de faire face aux défis que cette révolution présente dépend non seulement de la manière dont nous comprenons notre propre situation, mais aussi du caractère général des changements structuraux que cela entraine, surtout aux États-Unis peut-être.

L'Institut est heureux d'être en mesure de publier cette étude. Celle-ci devrait permettre d'informer le public sur certaines questions pressantes relatives au marché du travail et, à plus vaste échelle, sur l'ordre du jour politique de l'économie de l'information, et d'en stimuler la compréhension.

A.R. Dobell
Président

Mars 1989

The Authors

As an undergraduate, **Lars Osberg** attended Queen's University, Kingston, and the London School of Economics, graduating from Queen's in 1968. From 1968 to 1970 he was employed as an economist by the Tanzania Sisal Corporation, Tanga, Tanzania. He received his Ph.D. from Yale University in 1975 and taught at the University of Western Ontario before moving to Dalhousie University in 1977, where he is now professor of economics. He is the author of *Economic Inequality in Canada* (1981), *Economic Inequality in the United States* (1984) and numerous journal articles. He is married, with three children, and coaches soccer in the summertime.

Edward Wolff received his baccalaureate from Harvard College in 1968 and his Ph.D. from Yale University in 1974. Since then, he has been teaching at New York University, where he is now professor of economics. He is also a former research associate at the National Bureau of Economic Research and is currently managing editor of the *Review of Income and Wealth*. His current research is in the areas of household wealth distribution, Marxian economics, and productivity growth. He is the author of many articles and two books, *Growth, Accumulation, and Unproductive Activity: An Analysis of the Postwar U.S. Economy* (1986) and *International Comparisons of the Distribution of Household Wealth* (1987). He is married and has two children.

William Baumol was born and raised in New York City. He received his baccalaureate with a major in economics and a minor in art from the College of the City of New York in 1942. After serving in the U.S. army in Europe during World War II, he returned to the London School of Economics, where he received his Ph.D. in 1949. Since then he has been teaching at Princeton University, and since 1970 he has held a joint appointment with New York University, where he is now director of the C.V. Starr Center for Applied

Economics. He is the author of more than a dozen books which have been translated into about as many languages. He has been president of four professional societies, including the American Economic Association. He is married, has two children and two grandchildren. Besides courses in economics, he also teaches wood sculpture at Princeton University.

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Executive Summary

One of the characteristic features of modern economies, such as Canada's, is the fact that most employees are not directly engaged in the production of useful goods or enjoyable services. The majority of workers in Canada are "paper pushers", whose jobs are based on the production, distribution and use of information. Over the last two decades there has been a steady growth of business and commercial services, public administration and finance, as well as dramatic declines in the costs of information storage and transmission due to the revolution in computer and telecommunications technology. Moreover, declining costs of information management have encouraged changes in the structure of establishments and industries, as well as an increased provision of information services, and firms have increasingly subcontracted traditional management and administrative functions to outside providers of business services.

The growth of subcontracting implies that industry based classifications of economic activity are becoming increasingly unreliable, and this volume therefore emphasizes trends in the occupational composition of the labour force. Chapter 1, by Lars Osberg, distinguishes three broad occupational sectors within modern economies: the goods sector, composed of occupations whose duties directly involve the manipulation or transformation of goods; the personal services sector, whose occupations involve service to other individuals and the information sector, whose occupations involve the production or manipulation of symbolic information. Within the information sector we distinguish between the production of "data"—the routine manipulation, storage and transferal of information within previously defined categories (e.g., clerical work), and the production of "knowledge"—the establishment of original categories or analyses (e.g., engineering or computer programming).

Our argument is that growth in modern economies is inherently unbalanced because labour productivity grows at different rates in the different occupational sectors. Labour productivity in goods and data production grows steadily over time due to increasing capital intensity of production and the impact of advances in computer and telecommunications technology. However, labour productivity in the personal services and knowledge sectors shows much less tendency to increase over time, since labour time *is* the output in personal services occupations and the human creativity essential to knowledge production shows little tendency to increase over time. These differentials in the rate of growth of labour productivity imply that the fraction of the labour force engaged in goods and data production will tend to fall relative to employment in the personal service and knowledge sectors.

In Chapter 2, Edward Wolff and William Baumol decompose shifts in the occupational structure of the U.S. economy over the period 1960 to 1980. The most important factor in the greater relative importance of knowledge workers within the information sector is a relative shift *within* industries towards knowledge based occupations. As well, industries with lagging average productivity growth tend to increase their employment share, but very little of the growth in the information sector can be explained by shifts in final demand toward information-intensive output.

What implications will shifts in the occupational structure of the labour force have for the determination of individual earnings and for the distribution of earnings? In Chapter 3, Osberg demonstrates that higher education does not imply higher individual earnings for those employed in the goods and personal services sectors, but post-secondary education *is* strongly rewarded within the information economy. The occupational structure will be increasingly dominated in future years by occupations in which post-secondary education is highly valued. However, shifts in the relative importance of occupational sectors in future years can be expected to have offsetting impacts on the aggregate distribution of earnings. A shift of employment out of goods processing occupations and into personal services is a shift from a sector with relatively high average earnings and low inequality to a sector with relatively low average earnings and high inequality. On the other hand, the shift from data to knowledge based occupations is a shift from a low average wage, high inequality sector to a high average wage, low inequality sector. Since these shifts have offsetting impacts on the aggregate inequality of labour earnings, even relatively large changes in these directions should have a relatively small net impact on the aggregate inequality of earnings.

This volume does not, therefore, emphasize the impact of a growing information sector on social inequality. Nonetheless, changes in the occupational structure raise a host of policy issues, and in Chapter 4 Osberg discusses the educational policy, research and development and international trade issues raised by the pattern of unbalanced growth characteristic of the information economy.

Abrégé

L'une des caractéristiques des économies modernes du genre de celle du Canada, c'est que la plupart du personnel qu'elles emploient ne se trouve pas directement impliqué dans la production des biens et des services dont on peut jouir immédiatement. La majorité des travailleurs, au Canada, sont des "bureaucrates" dont la raison d'être est de produire, de répartir et d'utiliser l'information. Au cours des deux dernières années, on a assisté à une croissance régulière des services commerciaux et d'entreprise, de l'administration et des finances publiques, en même temps qu'au déclin spectaculaire des coûts en matière de stockage et de transmission de l'information, du fait de la révolution intervenue dans les technologies de l'informatique et des télécommunications. En outre, la diminution des coûts de la gestion de l'information a favorisé les transformations structurelles dans les entreprises et les industries, et a en même temps permis d'augmenter la fourniture de services d'information; les entreprises ont été de plus en plus en mesure de sous-traiter la gestion traditionnelle et les fonctions administratives à des fournisseurs de services dans le domaine des affaires.

L'augmentation de la sous-traitance a pour conséquence de rendre de moins en moins fiables les classifications des activités économiques à partir des types d'industrie et le présent ouvrage a précisément pour objet de mettre en relief les tendances actuelles dans la manière dont se répartit la main-d'oeuvre. Le chapitre 1, dû à Lars Osberg, distingue trois secteurs économiques principaux dans les économies modernes, à savoir: le secteur des biens, dont les activités supposent la manutention ou la transformation des produits; le secteur des services personnels, c'est-à-dire la fourniture de services à des tiers et le secteur de l'information, qui englobe les activités de production et de traitement de l'information symbolique. À l'intérieur du secteur de l'information, il faut distinguer entre la production d'"applications", c'est-à-dire le traitement, le stockage et le transfert

routiniers de l'information dans le cadre de catégories définies précédemment (par exemple le travail de bureau) et la production de "concepts", c'est-à-dire la mise au point de catégories ou d'analyses originales (par exemple en génie ou en programmation informatique).

L'argument de base est que la croissance dans les économies modernes se trouve fondamentalement déséquilibrée du fait que la productivité de la main-d'oeuvre n'augmente pas à un rythme identique dans tous les secteurs professionnels. La productivité de la main-d'oeuvre dans le secteur des biens et de la production des données augmente régulièrement au cours des ans, du fait de la progression de l'importance en capital de la production et de l'impact des progrès technologiques en informatique et télécommunications. Toutefois, le rendement de la main-d'oeuvre dans les secteurs des services personnels et des concepts a beaucoup moins tendance à augmenter avec le temps, puisque le temps de travail *est* ce qui résulte des occupations des services personnels et que la créativité humaine, essentielle à la production de concepts, a très peu tendance à s'accroitre avec le temps. Il résulte de ces différences sectorielles dans le taux de croissance de la productivité de la main-d'oeuvre que la part de la main-d'oeuvre engagée dans la production des biens et des données aura tendance à diminuer par rapport aux effectifs employés dans les secteurs des services personnels et des concepts.

Dans le chapitre 2, Edward Wolff et William Baumol analysent les transformations survenues dans la structure de l'emploi aux États-Unis au cours de la période allant de 1960 à 1980. Du point de vue de la prépondérance relative des concepteurs dans le secteur de l'information, le facteur principal semble être une tendance *interne* de ces industries à renforcer l'importance relative de cette catégorie d'employés. Les industries dont la croissance moyenne de productivité manque de dynamisme sont également portées à augmenter leur pourcentage de main-d'oeuvre. Pourtant, seule une faible partie de la croissance dans le secteur de l'information peut finalement s'expliquer par des changements dans la demande finale en faveur de produits informatisés spécialisés.

Quels effets les transformations survenues dans la structure de l'emploi auront-elles sur la manière de déterminer les salaires individuels et sur la répartition des revenus? Dans le chapitre 3, M. Osberg montre bien que le fait d'avoir fait des études ne se traduit pas nécessairement par de meilleurs salaires dans les secteurs des biens et des services personnels mais que, par contre, dans le secteur de l'information, les diplômes postsecondaires *sont* reconnus et très bien rémunérés. La structure de l'emploi, dans l'avenir, sera de plus en plus caractérisée par des postes destinés en priorité à ceux qui auront fait des études postsecondaires. Cependant, dans les années qui viennent, on peut s'attendre à ce que les changements dans l'importance relative des secteurs de l'emploi aient des effets compensatoires sur la répartition globale des revenus. Une variation de l'emploi au détriment de la production et de la transformation des biens et au profit des services personnels est en fait le passage d'un secteur où les salaires, dont la moyenne est relativement élevée, sont sensiblement égaux les uns par rapport aux autres, à un secteur où ils sont très inégaux entre eux et relativement bas. Mais d'un autre côté, le passage du secteur des emplois d'application vers celui de la conceptualisation est en réalité le passage d'un secteur où les salaires sont peu élevés et très inégaux vers un autre où ils sont élevés et présentent peu de disparité entre eux. Puisque ces variations ont des effets compensatoires sur l'inégalité globale des salaires, même les changements considérables dans ces diverses directions devraient avoir des effets, en définitive, peu importants quant à l'inégalité globale des salaires.

Ce volume, par conséquent, n'insiste pas sur le rôle qu'un secteur de l'information en expansion pourrait avoir sur les inégalités sociales. Pourtant, les changements qui se poursuivent dans la structure de l'emploi soulèvent une quantité de questions d'ordre politique, et M. Osberg en fait l'examen au chapitre 4. Ces problèmes, issus de la tendance à une croissance déséquilibrée caractéristique de l'économie de l'information, portent sur la politique en matière d'éducation, sur la recherche et le développement et sur le commerce international.

Chapter 1

Introduction

Lars Osberg

This book represents an attempt to probe beneath the surface of the information economy. We start from the fact that most people, in their daily work in advanced economies, do not directly produce useful goods or enjoyable services, rather they "push paper". If we look at what most workers are actually doing when they are on the job, we observe that they typically spend their time in meetings or on the telephone, at their desks or at their computer terminals. The daily task of most workers, most of the time, is to alter the symbols which are written on pieces of paper (or on magnetic tapes or disks) and sometimes to add new symbols to those already encoded on these media. As chapter 2 indicates, the fraction of the labour force in advanced economies that is engaged in the production of such information (whose consumption is *not* usually a direct source of utility to consumers) is increasing steadily over time.

Why is it that advanced economies are increasingly dominated by the production, transmission, storage and sale of information? What implications will the massive advances in computer technology of recent years, and the dramatic cut in the cost of transmission and manipulation of data which it enables, have on advanced economies? What difference does it make for individual earnings or for the inequality in earnings? Although we cannot hope to provide a definitive answer to these questions in only one book, we hope that this volume will serve to advance the debate on these fundamental issues.

The debate is important because it is hard to get used to the idea that the production of information is now the central activity of modern economies. It is much easier to think of economic activity in terms of the production of goods. Elementary text books in economics can easily present examples of the marginal productivity of labour in the production of "widgets", but it is much harder to demonstrate how adding an additional engineer to a project team increases the value of the output of engineering services. Statisticians can measure the revenue of law firms, but whether increases in revenue correspond to increases in the price of services or to increases in the quality or quantity of legal services is impossible to tell. With no conceptual framework to analyze services and with little data to serve as a base for discussion, it is not surprising that debate on economic issues tends to focus on the goods sector.

As a result, even though our cities are dominated by skyscrapers filled with people who work at desks, it is sometimes difficult to figure out where the wealth comes from. And there is a long tradition of thought which views information processing as, in essence, a parasitic activity which does not create "real" value.[1] The tradition that "real" wealth and "real" jobs come from goods production has been particularly important in a country such as Canada. Since much of Canada's economic history has been dominated by the export of a few natural resources, and since some of Canada's regional economies remain resource-dependent, Canadians have long thought of their economy as "resource-based". The traditional fear has been that Canada will remain a nation of "hewers of wood and drawers of water" and the traditional objective of industrial policy has been the creation of a manufacturing sector, comparable to that of the U.K. or the United States. Somehow these preoccupations continue, despite the fact that for several decades most of the Canadian labour force has actually worked in the service sector.

One implication of this pre-occupation is the tendency of subsidy dollars to flow to projects (such as northeastern B.C. Coal or the Hyundai plant in Quebec) which have "real" outputs and create "real" jobs. A second implication is that debate on crucial national issues, such as the 1987 Free Trade Agreement with the United States, often simply omits the service sector.[2] A third implication is the fact that our statistical data collection, our economic analyses and our taxation and subsidy policies pay a great deal of attention to investment in the fixed capital which the goods sector requires but virtually no attention to investment in the human capital which the information sector needs.

In this book, we offer a different emphasis. Our analysis is based on the supposition that the economy can usefully be divided into three productive sectors – those activities which produce goods, those which produce personal services and those whose product is information. We wish to emphasize the idea that "information" can be "data" or "knowledge" and to distinguish between the production of "knowledge" – i.e., the generation and dissemination of new conceptual categories, relationships or hypotheses – and the production of "data" – the manipulation, transmission and storage of symbolic information within previously defined categories. Our argument is that these two activities *together* comprise what has been labelled the "information economy", but these two component activities within the production of "information" are subject to very different economic forces in the longer term.

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[1] E.g. K. Marx (1893) has often been interpreted as arguing that accounting and sales labour do not create use value.

[2] Despite the fact that one of the innovations of the FTA was its inclusion of the service sector, analysis of it has largely been limited to assessment of the implications of tariff reductions for goods (e.g. Magun *et al.*, 1987).

Before introducing this argument in more detail, we discuss first (section 1.1) the distinction between services and the goods sector of the economy, since it is the information and personal services sectors which together comprise, in aggregate, the "service sector". However, any discussion of "sectors" of the economy presupposes some classification of economic activity. As Fuchs (1968: xxiii) has put it, "The service sector has long been the stepchild of economic research," but a number of definitions of it have been used in the literature. Section 1.2 then introduces an alternative basis for categorization and Section 1.3 presents the basic model underlying this volume.

1.1. The Definition of the "Service" Sector

Traditionally, the definition of the "service" sector has been fairly ad hoc. The paradigm cases for the goods sector are establishments in manufacturing, agriculture and resource extraction. Automobile factories, wheat farms and coal mines produce clearly definable physical products – outputs which exist independently of the identity of the purchaser or the labourers involved in production or the social relationship between the two. Productivity, in the sense of the ratio between inputs and outputs, is a clearly definable and physically measurable concept in principle, even if subject to considerable measurement problems in actual statistical practice. In some cases (e.g., Fuchs (1968), Norsworthy and Aanstead (1985)), the service sector is simply defined by exclusion as "all other economic activity".

However, if one follows the tradition, as in Debreu (1959:28), of defining a "commodity" as "characterized by its physical properties, the date at which it will be available, and the location at which it will be available," then transportation services can be seen as a special type of commodity production where a good at location B is the output of a productive process whose inputs were a similar good at location A, plus labour, gasoline, wear and tear on capital goods, etc. Following this perspective, one should exclude transportation activities from the service sector and, perhaps for this reason, such has often been the practice – see Fuchs (1968) or Stanback (1979).

However, restaurant meals and building cleaning services are invariably considered to be "services", although from one perspective the role of cleaners is to remove dirt and the function of a restaurant is to produce the output "a cooked meal on one's plate" from the inputs of labour time, capital and uncooked food. Perhaps we feel a restaurant meal to be different from manufacturing since we know that the personal relationship between the waiter/waitress and the customer can have a major impact on the utility derived from the commodity (e.g., a surly waiter can spoil the enjoyment of a meal) but this basis for distinction between goods and services can become rather fine. Establishments which produce frozen TV dinners are usually judged to be involved in the production of "goods" while those which produce takeout pizzas are said to be engaged in the production of "services" – but one would not wish to say that this is because goods are cold while services are hot. As well, the same good may sometimes be classified differently, depending on its packaging – e.g., bottled water is considered to be a good, while tap water is seen as a public utility, which may or may not be classified as a service.

If we are to discuss structural change in the economy, we have to have some definition of sectors, and some authors have tried to base their classification on the nature of an establishment's product. For example, Stanback (1979:5) argues that "production of 'goods' results in a material product that is typically storable and transportable. Production of 'services' results in an output that is not storable and usually requires direct interaction with the customer."[3] Other authors (e.g., Fuchs (1968:16)) have eschewed an attempt at a conceptual definition of services, and have contented themselves with defining the service sector by listing the included industrial categories of employment or output – *as classified on an establishment basis*. Since these criteria do not coincide, Fuchs' conclusion of two decades ago still stands "More than a decade ago George J. Stigler wrote 'There exists no authoritative consensus on either the boundaries or the classification of the service industries.' A careful review of subsequent studies provides no basis for challenging this conclusion. . . . The differences to be found among empirical studies reflects the absence of any clear theoretical basis for grouping industries. The two criteria most frequently mentioned are closeness to the consumer and the presence or absence of a tangible product." (1968:15-16)

Perhaps it is partly due to these difficulties of classification that the emphasis in modern economics is on quantitative as opposed to qualitative analysis, and much of modern economic thinking has simply ignored the distinction between goods and services.[4] If one thinks of marketed output as the production and exchange of "commodities", analysis of the modern economy can proceed without reference to what is being produced or how. But such analysis also cannot help us understand the process of structural change or predict its implications. And there is a very widespread concern that the growth of service sector employment is a distinctly "bad thing", because low-paying jobs in the personal service sector are replacing middle-income positions in goods production (Blackaby, 1978 or Bluestone and Harrison, 1982). If this is true, then the trend to service sector growth may also be a trend to a bi-polar society of "yuppies and nannies", where a small elite have well-paid professional careers and the vast majority hold low-wage, menial service jobs.

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[3] However, in practice, Stanback includes among "services" those activities which we will label as the "information" sector despite the fact that information is both storable and transportable. The existence of "tangible" output is therefore the key aspect of this definition.

[4] We would argue that the general equilibrium conceptualization of the economy has been very influential in shaping economists' intellectual framework. Debreu (1959:32) argued, "A commodity is a *good or a service* completely specified physically, temporally and spatially (emphasis added)." Note that this definition ignores the problem of specifying physically that which is non-physical – e.g., information.

1.2. The Information Sector in the Modern Economy

Discussion of trends in the service sector, therefore, combines some very real problems of definition and measurement with a widespread social concern and the perception that something quite dramatic is happening to the costs of processing and transferring information. How best to proceed? In this section we argue for a logically consistent classification scheme based on the smallest observable unit of economic activity – the occupational role.

We emphasize the occupational role as a basis for the classification of economic activity because individual workers are aggregated into establishments of employers, and establishments may be combined within firms, *but this aggregation occurs largely on the basis of the relative costs of alternative methods of managing the information flows required to co-ordinate economic activity*. As Coase (1937) noted long ago, "firms" exist because it is cheaper to organize some activities outside the market – i.e., the boundary conditions of firms are set by the relative costs of market and non-market organization. If the costs of managing information are subject to rapid change, it follows that firms will expand or contract (by amalgamation or subcontracting) as a result of the trends in the costs of information processing whose implications we wish to analyze – hence measurements based on "industry" or "firm" may be seriously misleading.

Our fundamental starting point, therefore, is the occupational role[5] – the set of job actions – of individual workers. We argue that one can, in principle, think of the job actions of an individual worker as doing something to things, to people, or to symbols. To put it somewhat differently, a worker produces goods, personal services or information.

Of course, we recognize that such a classification necessarily represents a very substantial compression of the enormous diversity of human work activity. At the four digit level of occupational classification, the Canadian Classification and Dictionary of Occupations recognizes approximately 500 distinct occupations, which span the spectrum from sales clerk to nursing assistant to aircraft fabricator and assembler. Yet even this level of detail is not sufficiently precise for some purposes. For manpower planning purposes at the micro level, universities have to distinguish between university teachers of english literature and university teachers of economics (indeed, teachers of economic history usually have quite different skills from econometricians). Similarly, shipbuilding firms must know the difference between oxyacetylene welders and specialty arc-welders. For some purposes, *very* detailed classification of occupational roles is required, but it is difficult to see the changes in a forest if one concentrates one's attention entirely on individual trees. Since we want to focus on long term changes in economic activity, this volume will paint with a broad brush. Although such aggregation of occupational roles into occupations which produce goods, personal services or information cannot be of much assistance in the details of short-run manpower planning, it can help us to discern and to explain long-run trends in the aggregate composition of the labour force.

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[5] The more conventional approach to the "information economy" is to use industry data on employment to define the "information sector" – see Porat (1977) or Machlup (1980). We reject this approach for the reasons cited below.

In this three-way classification, it is easy to think of "paradigm cases" such as assembly line workers, hairdressers or computer programmers, whose day-to-day job actions are clearly, and almost entirely, specialized to one of producing goods, personal service or information. As well, one can think easily of occupations which combine types of activities—e.g., a psychiatrist, who provides both emotional support (a personal service) and diagnosis of an illness (an intellectual activity). Occupations which combine aspects of goods production, personal service and information provision create problems of classification, but detailed occupational titles can in the vast majority of cases easily be assigned to one of these three categories.[6] (In Chapters 2 and 3 we test the robustness of our conclusions to alternative possible operationalization of our categorization scheme.)

However, we emphasize that our distinction between sectors is *not* equivalent to a distinction between "tangible" and "intangible" output. Indeed, we argue that some occupational roles (e.g., fireman) whose output is "intangible" in the immediate sense should best be seen as contingent producers of goods. The role of a fireman is to put out fires, *if* they should occur, and in this sense his role is similar to that of a quality control inspector, who physically removes goods from the production process, *if* they are defective. Similarly, we do not view building cleaners as doing things "for" people, rather as people who remove dirt, i.e., act upon things. For these reasons, our discussion diverges from the more traditional conceptions of "public services" and "personal services", whose basis for classification of occupations is far from clear.

Furthermore, we emphasize that although many analysts (e.g. Fuchs, 1968 or Stanback, 1979) classify sectors of production on the basis of the *establishment* of operations, this is potentially highly misleading. An establishment is, by definition, composed of "a group of employees at a common work site under common management authority," but that aggregation of workers, and the relative weight of different types of work roles within it, changes over time, in response to the same economic forces which we wish to analyze. The reason for a common site for production lies partly in the shared use of indivisible capital goods in production, partly in reduced transfer time between operations but also largely in economies of control and coordination of work roles which are possible at a shared work site.

To take a specific example, we are all familiar with the engineering logic that says that to produce gasoline, one must gather certain specialized items of capital equipment and specialized occupational groups of workers at a common work site. But many people are less familiar with the fact that workers at that site may work for a variety of employers—e.g. maintenance contractors, catering companies, secretarial agencies or consulting engineer firms. Since an "establishment" is a collection of employees *under*

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[6] The largest number of "problem classifications" come from what have been labelled the "caring professions", such as psychiatrist, clergyman or medical doctor, which combine an element of personal attention with diagnosis and prescriptive treatment. The debate over "assembly line" medicine is perhaps indicative of the ambiguity of demands placed upon this occupational role.

common management authority, and since "industries" are statistically defined as aggregations of establishments with a common type of output[7], such employees are likely to be classified as members of the building cleaning industry, food service industry, business or professional service industry. Yet if the refinery's owners had chosen, they could have employed all these workers directly, in which case the workers would all have been classed as belonging to the petroleum refining industry. Economists would generally argue that the "make or buy" decision of whether to purchase goods and sub-contracted services on the open market or to organize their internal direct production will depend on relative costs – notably the relative costs of contract administration compared to the costs of direct control of employees.

We argue that the "command, control and coordination" function represents a large part of the function of the information sector. If the technology of these functions is subject to rapid change, it follows that the definition of establishments is endogenous to the process of technical change which we wish to discuss. And one would not wish to be misled into an impression of growth in the information sector if measurement of that growth was based solely on the numbers employed by establishments which provide producer services, since the growth in the number of such establishments partially reflects the "contracting out" of data processing, or other functions, previously done internally.[8][9]

In part, the information sector is involved in the creation and transmission of technology. Technology which is embodied in capital goods, or in the directly productive skills of individuals, is clearly directly useful in increasing the production of goods and services over time. However, most workers in the information sector are not engaged in industrial research and development or in the production of human capital in industrial training. Rather, most information sector workers are actually engaged in the "command, coordination and control" functions of advanced economic systems. (see Table 3.0, Chapter 3).

Travel agents do not provide a directly pleasurable personal service or produce a physical good, but they do perform the economically valuable function of coordinating an individual's travel plans with those of thousands of others and of controlling access to the physically productive activity of transportation. Similarly, banks and other financial institutions maintain records on the assets and indebtedness of individuals and enable the coordination of production and consumption plans over space and time, as well as controlling access to goods and services. Economists are, in general, somewhat ambivalent about these functions of the information sector, since these are the functions that "the market" is supposed to perform.

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[7] Establishments or firms with multiple outputs are assigned to "industries" based on a judgment of what their "major" activity is – the criterion is usually sales but it could be employment or value added. This creates the difficulty that IBM, which produces both computers and software, can be included among manufacturers when computer sales are strong but joins the business service sector when software sales are up. Over time, if the mix of output of multi-product firms is changing, industry classifications of employment can be quite misleading.

[8] See W.J. Howe (1986:29-36) who argues that "contracting out" explains much of the phenomenal growth (250%) in employment in business services between 1974 and 1984.

[9] The definition of a "common workplace" has also become increasingly difficult – for example, in the case of secretaries who receive dictation by telephone, transcribe into word processors at home and remit output by telephone line.

In a simple barter economy, individuals exchange clearly defined property rights and the interaction of buyers and sellers produces a unique system of prices which, under some conditions, has desireable welfare properties.[10] In a simple barter economy, all consumers (who are also producers) simply examine the parametrically given set of relative prices of commodities and, after themselves performing the calculations required to compute the utility maximizing amounts of goods to sell or purchase on commodity markets, they enter the market and exchange commodities. As many have noted, the assumption of "rationality" of economic agents means, in practice, that performing these maximizing calculations is assumed to have zero cost. Fundamentally, this is the model of general equilibrium from Debreu (1959) to the present day.

In economies which have evolved beyond simple barter, money exists as a means of coordinating the timing of individual purchases and controlling access to goods and services. However, in modern economies it is not the case that individuals simply carry cash with them to purchase, in the market place, whatever they need, wherever and whenever they need it. Instead, we observe large bureaucracies whose function is to command, coordinate, and control the activities of individuals – evidently operation of "the market" requires resources.

All this is *not* to say that the growth of the information sector "replaces" the market. Rather it would be more accurate to say that the growth of the information sector *extends* the market, and the specialization of function which it enables, into areas previously untouched by the division of labour. If we recognize that there always has been a cost to engaging in market transactions, we can examine trends in such costs – e.g., as affected by the development of information processing technology. For example, in the past only the very rich could afford to employ financial advisors, but the spread of personal computers and financial management software packages implies that an ever-increasing fraction of the population can have access to sophisticated financial planning.[11] Similarly, small retail outlets which used to have only a hazy idea of their inventory and per item profit margins can now know instantly, by pushing a button on their cash register. The operation of a "just-in-time" philosophy for manufacturing, where specialized parts are delivered from sub contractors to final assembly lines "as-and-when" needed, depends entirely on a timely and cheap flow of information to co-ordinate production plans.

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[10] For our present purposes, the assumption of zero transactions costs in general equilibrium analysis is the most important. As Hahn (1970) showed many years ago, the presence of transactions costs implies that the price system generated by a decentralized market economy cannot necessarily be said to have any desirable welfare properties. Examples of transactions costs invariably involve the costs of record-keeping as to the ownership of commodities, i.e., the creation and storage of information.

[11] One should note that when markets are created in information processing, the operating characteristics of markets in goods and services may well change. Individuals and institutions who purchase financial management optimization packages will behave differently as a result of such purchases. Even before the stock market crash of October 19, 1987, there was a concern (e.g., *The Economist*, June 18, 1986:76) that commodity and securities markets may have become more unstable in recent years as more market participants have purchased the same computer programmes for optimizing portfolio management strategies, which, fed the same information, will issue "buy" or "sell" instructions at the same time. The existence of this new market in financial management strategies offers the possibility of increasingly

The efficiency gains from the growth of the information sector are not simply to be found in the increased technical efficiency of individual workers and pieces of capital equipment. One must look as well to the economic efficiency gains obtained from better coordination and control of the activities of individual economic agents. Increases in the micro efficiency of the economy due to better coordination will, however, be very difficult to perceive if one starts from the theoretical perspective that "the market" optimally coordinates economic activity. Since one cannot improve upon perfection, believers in perfect markets will find it difficult to perceive efficiency gains from improved coordination of economic activities, or to explain the consequent growth in the information sector.

1.3 Long Run Trends in Labour Force Composition

If the major function of work roles is either to do something to a thing, to do something to a person or to provide information, then (barring substantial shifts in final consumption demand) long run trends in labour force composition will be driven by the differential rates of growth of labour productivity possible in each of these roles. Labour productivity in goods production has seen, and continues to see, substantial increases in part due to the accumulation of capital, and in part from improvements in the technology of production enabled by a rapidly expanding store of scientific knowledge. However, the essential aspect of personal service roles is the service which one individual performs for another – i.e., the labour time of the worker *is* the commodity which is purchased – hence labour productivity is inherently unable to increase over time.[12]

Some years ago, Baumol (1967) outlined the dynamic implications of a two sector model of the economy, where labour productivity increases over time in one sector (the

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destablizing speculation since it is always in the interest of any individual market participant to purchase the "most popular" software package for financial management and thereby reap the capital gains which accrue when one buys just as the market moves up, i.e., when everyone else does. (For a slightly different model of destabilizing speculation, see Denton (1985)). As Keynes pointed out many years ago, in betting on a beauty contest, the winning strategy is not to select the contestant one thinks is most beautiful, rather the winning strategy is to select the contestant one believes the judges will think to be the most beautiful. If one believes the judges are using a computer programme, one will want to use the same programme – and place one's bets a bit faster!!

[12] One must distinguish between increases in labour productivity and the increases in output obtainable from greater labour input, through increased intensity of work effort. Better scheduling can, for example, increase the number of patients whom a psychoanalyst can see in a working day by minimizing the time spent between patients, but this is effectively an increase in labour input, and a decrease in "on the job leisure".

"progressive" sector), but cannot increase in the other "stagnant" sector.[13] The basic implication of this model is that the output of the progressive sector grows increasingly cheap over time as relatively less labour is required for its production. As less and less labour is needed in the progressive sector, an increasing fraction of the labour force will be needed in the stagnant sector if it is to remain in existence – despite the increasing relative price of stagnant sector output.

More formally, the two sector model (where sector 1 is stagnant and sector 2 is technologically progressive) can be put in terms of equations (1) and (2).

$$(1)\quad Y_{1t} = a\ L_{1t}$$

$$(2)\quad Y_{2t} = b\ L_{2t}\, e^{rt}$$

where:

a, b = technologically defined constants.

Y_{it} = output of sector i in period t

L_{it} = labour employed in sector i in period t

r = rate of growth of labour productivity in sector 2

If the economy is competitive and if labour is mobile between the two sectors, wages (w_t) will grow at the same rate of increase as the increase in labour productivity as per equation (3), implying that the cost of the two types of output is given by (4) and (5).

$$(3)\quad w_t = w\ e^{rt}$$

$$(4)\quad c_1 = w\ e^{rt}/a$$

$$(5)\quad c_2 = w/b$$

Since stagnant sector output becomes relatively more expensive over time, the fate of the stagnant sector depends on whether the income elasticity of demand exceeds the price elasticity. To be concrete, personal service workers and the performing arts have often been identified as quintessential "stagnant" activities.[14] This model has been used to explain (1) the increasing relative price of such activities, compared to manufactured goods, and (2) the financial difficulties faced by governments who supply educational, cultural and social services.

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[13] To simplify the discussion we assume throughout this section that labour productivity growth in the "stagnant" sector is zero. This is an extreme assumption. All that we really need to assume is that productivity growth in the "stagnant" sector is less than productivity growth in the "progressive" sector. All our results hold in the more general case, but the algebra is messier – see Inman (1985).

[14] The labour productivity of a viola player in the live performance of a string quartet is inherently constant. Reproduction of the performance produces a different commodity, recorded music, whose production can be seen as "asymptotically stagnant". See Section 4.2 for a discussion of the policy issues raised by ever cheaper, and better, reproduction technology.

More recently, Baumol, Blackman and Wolff (1985) have introduced the idea of an asymptotically stagnant sector – one which uses, in fixed proportions, one group of inputs produced by technologically progressive activities and another group of inputs which are technically stagnant. In formal terms, we have a third type of output, as in equation (6).

$$(6) \quad Y_{3t} = \min[\alpha L_3, \beta L_4 e^{\delta t}]$$

where:

α, β are technological constants.

L_3 is labour used in the 'stagnant' input

L_4 is labour whose productivity rises over time.

Clearly, the ratio of employment in "stagnant" inputs to technically progressive inputs is given by equation (7), and that ratio increases over time at the rate δ.

$$(7) \quad L_3/L_4 = \beta e^{\delta t}/\alpha$$

The term "stagnant" may be thought to be pejorative, but it really refers to those human activities which cannot be replaced. Baumol, Blackman and Wolff argue that in television broadcasting, which has experienced substantial technical change in the production and transmission of film, program expenses have risen substantially more rapidly than technical expenses since substitution of capital for actors is not generally possible. Computer centers, which twenty years ago employed large numbers of key-punch operators, have seen substantial technical progress and now mainly employ computer programmers and system operators.

Indeed, empirical research in economics provides, itself, one of the clearest examples of "asymptotic stagnancy" since it requires both the conceptualization of a new model of the economy, and the processing of a large amount of data. When Tinbergen developed his pathbreaking econometric models of the Dutch economy in the 1930s, a certain amount of inspiration was required, as well as several rooms full of clerks, who computed manually the estimated ordinary least squares (OLS) regression coefficients of the model. Today, it is no easier to have a new idea, but the labour time required to estimate OLS regressions is trivial.

A final example comes from the world of banking, which has always combined a need for accurate record-keeping and for creative financial planning, risk assessment and deal-making. When the author's grandfather entered the employ of a British bank in the 1890s, he was initially employed as a "copy clerk", manually copying correspondence for the files. The invention of carbon paper increased labour productivity in record-keeping, as did the later advent of punched cards and the electronic computer. Automatic teller machines carry the process to its logical conclusion – the labour required for data entry and record-keeping is supplied by the customer. Yet employment as a loans officer still requires non-routine risk assessment and personal judgement. The proportionate importance of non-routine labour, as opposed to labour involved in the manipulation of data, has undoubtedly increased.

The common element in all these examples is the replacement of people who used to perform routine calculations or transferrals of information (i.e. copy clerks, key-punch operators, clerical research assistants) by information processing technology. We think of these workers as producers of "data" and distinguish their occupational role from that of "knowledge" producers, whose work cannot be routinized in the same way.[15]

We therefore identify the personal service sector as "stagnant" and goods production as technically progressive. Symbolic information can be seen as composed of data and knowledge – hence the information sector is asymptotically "stagnant". The production of information partly involves the routine compilation, storage and transmission of data – and rapid decline in the costs of electronic computing and telecommunications imply very rapid rates of increase of labour productivity. However, the solution of a new problem, or the generation and dissemination of new conceptual categories, relationships or hypotheses (i.e. the production of "knowledge") still requires the intervention of human creativity, and we have no reason to believe that the capacity for human creativity has increased much over time.

The empirical predictions of this framework are therefore, fairly clear. Since the consumption of personal services has not shown any long run tendency to decline (see Chapter 2), the increased relative productivity of labour in goods production implies that employment in goods producing occupations will decline relative to employment in personal service occupations. Information (i.e. routine data and knowledge) can be seen as an input into the production of goods and personal. Within the information sector, one can expect "knowledge" workers to increase in relative importance, while employment in data based occupations decreases steadily over time. The purpose of this volume is the implications of these trends in the occupational composition of the labour force for trends in wage determination, social inequality and public policy.[16]

However, two caveats are in order. First, one must emphasize that the occupational composition of the labour force changes rather slowly over time, although the cumulative effect of such change can be quite significant. In 1901, some 18.9% of those employed in Canada were classified as managerial or professional, a proportion which hardly changed for 60 years – in 1965, 19.1% of the labour force was in managerial, professional and technical occupations.

However, over the last twenty years, which also happens to be the major period of spread of computer technology, the managerial/professional/technical occupations have grown to 28.0% of the labour force.[17] Over the 1965 to 1985 period the share of the Canadian labour force that is managerial/professional/technical has grown by 1.6% per annum. If this category of occupations continues to grow at the rate of the last twenty years, it will expand to 36.5% of the Canadian labour force by the year 2005. Clearly, such simple-minded extrapolation does *not* constitute a valid prediction of future trends – but it does illustrate that the order of magnitude of recent shifts in occupational composition can produce significant, if gradual, shifts over time.

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[15] For a more formal distinction, see Chapter 3, Section 3.1.

[16] Note that there is no prediction here as to how large the information sector will be in Canada, relative to the non-information sector, only predictions on trends *within* these sectors. Information is easily traded internationally, hence the size of the information sector *in total* depends heavily on where Canada will place in the *international* division of labour - i.e., some countries have clear strategies to specialize in the export of information, rather than commodities. Bull *et al.* [1986] discuss some of the trade and industrial structure issues involved in computer services).

Secondly, one must emphasize that our focus is on long-term secular trends. Since many occupations require long and expensive periods of training, the focus on long run trends in occupational demand is appropriate for many aspects of educational and social policy. However, such policies may not necessarily appear appropriate in the short run.

As an example, one can cite the projections of occupational demands for labour made in the period after the 1979 increase in world oil prices, when there was a widespread expectation that energy prices would only go up. At that time, medium term projections of labour demand were often based on the premise that the development of alternative sources of energy supply would play a major role in employment creation, throughout the 1980's. The "Dodge report" in Canada forecast an emerging surplus of university trained manpower and a deficit of workers in the skilled construction trades in Canada in the mid 1980's (see Employment and Immigration Canada, 1981 pp. 45-69). Such predictions were, however, entirely contingent upon the prediction of an increasing relative price for energy and were invalidated by the 1982/83 recession and the collapse of oil prices in 1986. In 1986-87, unemployment rates of over 20% were common among exactly the occupational groups which the 1980 forecasts said would then be in extreme demand! In the medium term, fluctuations in the relative prices of commodities will clearly imply fluctuations in the demand for labour by occupation – the model we are discussing attempts to look at the long run trend in the occupational composition of the labour force, abstracting from such temporary fluctuations in relative commodity prices.

1.4. Outline of this Volume

Section 1.3 has outlined the implications for the composition of the labour force of differential rates of growth of labour productivity, *given* constant output proportions. We noted above that we wish to abstract from the short-run fluctuations in labour demand caused by temporary fluctuations in relative prices. The question remains, however, whether there are long run trends in the composition of final output, which would necessarily affect the derived demand for labour of different types and trends in labour force composition.

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[17] Historic figures from Ostry and Zaidi (1972: pp. 88 & 92); 1985 data from Statistics Canada 71:001 12/85, p. 101 and 105). Note that the 1901 base is employment, while the 1961 basis for comparison is labour force.

To fully answer the question of whether shifting output proportions invalidates, or accentuates, the implications of unbalanced productivity growth discussed above we would need to specify an exact model of aggregate demand. In particular, one should specify the relative information-intensity of the commodities which individuals and governments consume, and the income elasticity of demand of those commodities. If it is true, for example, that commodities with high income elasticities of demand embody relatively more information labour, then the prediction would be that information sector employment would grow over time as relatively more of such commodities are produced.[18]

However, in Chapter 2 our finding is that shifts in the composition of final demand have had relatively little impact on the demand for information workers in the U.S. over the period 1960 to 1980. We find a slight trend to an increasing proportion of knowledge workers in the labour force due to shifts in the composition of final output, but the effect is minor. The aim of this volume is to decompose recent trends in labour force composition, to assess their implications for earnings and to discuss policy implications. We leave to further research the important problem of "closing the model" and explaining the trend in composition of final output.

Chapter 2 of this volume therefore focusses on structural transformation in the American economy over the last two decades, and decomposes the occupational transformation of the American labour force into the effects of substitution in production due to asymptotic stagnancy, shifts between industries due to unbalanced growth and shifts in relative demand for output.

Chapter 3 examines pay determination within the information sector. If the information sector is growing in relative importance within modern economies, and if the production of knowledge can be expected to be an increasingly large fraction of that activity, then the distribution of income within these sectors will have an increasingly heavy weight in the distribution of income in society as a whole. Furthermore, if the mechanisms of individual income determination differ between employment sectors – specifically, if "credentialism" is more characteristic of the knowledge sector than of other sectors, then one can expect, over time, gradual changes in the mechanisms determining individual income in the broader society.

Finally, chapter 4 examines the appropriate institutional response to these emerging trends and suggests avenues for further research.

Although the typology of "knowledge" and "data" workers used in this volume was developed independently, it has come to our attention that it bears some resemblance to a point made in Machlup's pathbreaking work "Knowledge and Knowledge Production" (1980). In the 1980 volume, the following quotation from Machlup's original work of 1962 appears: "producers of knowledge may, however, work on very different levels: they may be transporters, transformers, processors, interpreters, or analyzers of messages as well as original creators. What I have failed to do in this volume, and would do if I had time for it, is to attempt a statistical separation of knowledge producing activity by these different levels. Perhaps I shall undertake this task as a sequel to the present book: or perhaps someone else will want to do it, especially with reference to the changes in the occupational structure, discussed in the last chapter of this volume." (1980:17)

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[18] In the government sector, one might use as an example the increasing technical sophistication of weapons, the greater importance of procurement in the defense budget and the fact that most of the cost of new weapons systems now consists of the software design of the computer systems which run them. In household consumption, one could compare the information intensity of housing and shelter costs with that of consumer electronics.

In many ways, this 1962 statement can be seen as a precursor to the distinction between the production of "data" and "knowledge" which we insist on throughout this volume.

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Chapter 2

Sources of Postwar Growth of Information Activity in the United States

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Edward N. Wolff and William J. Baumol***

> "By virtue of this concentration of processes the modern industrial system at large bears the character of a comprehensive, balanced mechanical process. . . . The higher the degree of development reached by a given industrial community, the more comprehensive and urgent becomes the requirement of interstitial adjustment." Thorstein Veblen, *The Theory of Business Enterprise* (New York, 1904), p. 16.

The explosive expansion in the share of the labour force engaged in information related activities has been documented by, among others, Machlup [1962], Porat [1977] and Beniger [1986]. This chapter offers more evidence to this effect, as well as an extension of the required classification scheme. However, the more interesting questions are "why?" and "so what?" The main purpose of this chapter is a first step toward assessment of the sources of this development, which may in turn shed some light upon its significance.

One explanation of the explosion in information employment is that it represents a major upheaval in the nation's way of doing business – i.e. the increasing complexity and technical sophistication of our economic activities and the expanding interrelationship among them makes an increase in acquisition and use of information indispensable. Yet there is another possible explanation which may either complement or compete with the preceding interpretation. Because they are services, information acquisition and dissemination may be under a handicap relative to manufacturing in achieving productivity growth. If so, a relative rise in employment in information services may simply reflect a relative decline in employment in manufacturing that is dictated by the comparatively rapid rise in manufacturing productivity. After all, rising productivity means that fewer workers are needed to do a given job. To the extent that this is true, the comparative rise in information employment represents a reactive redeployment of the labour force away from sectors of the economy where the need for it is lagging. Our study is, apparently, the first empirical investigation of this issue. Its results indicate that the information employment explosion is due almost entirely to the latter effect.

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* New York University.

** Princeton and New York Universities.

I. The Analytic Approach and Some Preliminary Considerations

Three issues require discussion: the nature of our classificatory scheme, the structure of our underlying theory and the character of our empirical model. With regard to classification, any boundary in a two way classification of all economic activity between those activities that are information related and those that are not must inevitably be somewhat arbitrary. There is no one correct solution to this classification problem. We adopt a classification scheme closely related to those used by previous writers, but we note that our qualitative conclusions remain robust under substantial changes in the classification. This should not really be surprising, since the growth in the proportion of information workers must be evaluated by a comparison of that share at two different dates, and whatever classification one adopts remains the same at both dates. Further, the evidence indicates that the upsurge in information related employment has been so large that it will show up in the data, no matter what taxonomy is adopted.

The theoretical foundation of our analysis rests on two closely related economic models – that of unbalanced productivity growth and the asymptotic stagnancy model. The former focuses on sets of outputs and the latter on sets of inputs, both of which contain some items whose productivity grows far more rapidly than others'. The analysis then rests on the tautological observation that if there is no change in the proportion of two such disparate items produced or utilized, then the share of the economy's inputs devoted to the item whose productivity is relatively stagnant must increase in comparison with that of the item whose productivity is "progressive". Elsewhere, we have provided evidence that a good part of the much publicized "shift to the services" is illusory if it is interpreted to mean that there has been a shift toward increased consumption of services at the expense of manufactured and agricultural products (see Baumol, Blackman, Wolff [1985]). The data indicate that there has been very little change in the proportion of outputs of services and manufactures, in total. Rather, the relative stagnancy of a considerable subset of the services in terms of productivity has forced them to absorb a growing share of the economy's labour force, precisely because of the relative constancy of output proportions, and that has helped to create the illusion that a larger quantity of services is being supplied.

The formal model that is used here is really a tautology, a simple version of which we describe next. We decompose changes in the information workers' share of the labour force into three parts: (i) the *substitution*, within the production process, of information labour for labour of other types, (i.e., the change in proportion of information workers in each industry's labour force) – a process which we analyze in terms of the asymptotic stagnancy model of the productivity of occupations within industries; (ii) the change in industry employment levels associated with relative variations in the average *labour productivity* of the different industries; and (iii) the change in each industry's share of the economy's total *output*. The first of these three components can be interpreted as *ceteris paribus*, the extent to which the composition of the labour force in a typical industry has become more information intensive. If all output proportions had remained unchanged and if all industries had experienced the same rate of productivity growth, then element (i), would account for the observed rise in the share of information workers in the overall labour force. Component (ii) in our decomposition plays a critical part in enabling us to test the role of the unbalanced growth phenomenon in the information explosion. For if it were the only one of the three elements to undergo a nonzero change, that would imply that the entire information explosion of the labour force can be attributed to relative productivity growth of less information using industries, driving the labour force toward the remaining industries, those where information related labour is in relatively great demand. Finally, element (iii) in our decomposition relates to the output share of different industries and is pertinent in determining the extent to which the expansion in information-related employment is attributable to a shift in demand toward products with a high information content. For brevity, it is convenient to refer to these three elements, respectively, as (i) the production substitution component, (ii) the productivity lag component, and (iii) the output composition component.

The basic relationship that enables us to distinguish these three effects is readily described. Here we offer a simplified preliminary version that is easier to grasp intuitively than the matrix relationships that were actually used and which will be described later. We require some simple notation:

let M_j = the number of information workers in industry j

L_j = total employment in industry j

Y_j = total output in industry j

Then,

$$(1) \qquad M_j/\Sigma L_k = (M_j/L_j) \cdot [(L_j/Y_j)/(\Sigma L_k/\Sigma Y_k)] \cdot (Y_j/\Sigma Y_k)$$

or, considering changes between time t and t + 1 and letting, e.g., $(L_j/Y_j)_t$ represent the value of the fraction in parentheses at time t, we obtain

$$(2) \qquad \Delta(M_j/\Sigma L_k) = \Delta(M_j/L_j) \cdot \{[(L_j/Y_j)/(\Sigma L_k/\Sigma Y_k)]_{t+1} \cdot (Y_j/\Sigma Y_k)_t +$$
$$(M_j/L_j)_{t+1} \cdot \Delta[(L_j/Y_j)/(\Sigma L_k/\Sigma Y_k)] \cdot (Y_j/\Sigma Y_k)_t +$$
$$(M_j/L_j)_t \cdot [(L_j/Y_j)/(\Sigma L_k/\Sigma Y_k)]_{t+1} \cdot \Delta(Y_j/\Sigma Y_k)$$

Here, we can obviously associate $\Delta(M_j/L_j)$ with the production substitution component, $\Delta[(L_j/Y_j)/(\Sigma L_k/\Sigma Y_k)]$ with the (inverse of) the relative productivity lag component, since it reflects productivity gains in sector j relative to overall productivity growth, and $\Delta(Y_j/\Sigma Y_k)$ with the output composition component. Thus, for example, if the first two of these increments are zero then the RHS of equation (2) becomes its last term:

$$(3) \quad (M_j/L_j)_t \cdot [(L_j/Y_j)/(\Sigma L_k/\Sigma Y_k)]_{t+1} \cdot \Delta(Y_j/\Sigma Y_k)$$

which will contribute considerably to the relative use of information workers if *all three* of the parenthetic expressions in (3) are large, i.e., if industry j is one whose output share, $(Y_j/\Sigma Y_k)$, increases considerably, if the share of information workers in its labour force, (M_j/L_j), is high, and if its relative labour productivity, (Y_j/L_j), is low. This is precisely what we mean to include in the output share effect.

Equation (identity) (2) relates only to a single industry, j. However, it can readily be summed over a number of industries or the economy as a whole with no change in the structure of the equation. Thus, it can be used to extend our analysis to an entire sector or to the economy as a whole. This identity, then, along with several variants derived by various degrees of aggregation or disaggregation, is the basic relationship of our empirical analysis.

That analysis then proceeds by direct use of the available estimates of the input-output coefficients and the statistics on information workers, total employment and outputs by industry, simply substituting these data into (2). The proportions among the resulting terms, then, are taken to indicate the relative shares of the three components in the explosion of information employment in particular industries, in particular sectors, and in the economy as a whole.

The role of two of the components of (2) is unambiguous in terms of their implications about the source of the growing share of information labour. If the last term in (2), the output composition component turns out to be large, that must imply that consumers (or industry) shifted their demand patterns toward increased preference for information intensive goods and services, just as the term "information revolution" implies. It is possible, for example, that the world is growing more complex in fact (as well as in our awareness of complexity). If so, it may be necessary now to acquire more information (e.g., legal advice on pollution legislation) in order to produce the same amount of output.

On the other hand, a large productivity lag component has the reverse implication — that the shift in the labour force arises only because less labour is now needed in progressive industries. However, the remaining element, the input substitution component (the first term in (2)), is rather ambiguous. Increased use of information labour can arise because the information production activities within the industry grow relatively slowly in productivity, hence absorb an increasing proportion of the industry's employment. In this case, the number of information workers increases, not because of an increase in sophistication of the total production process which requires more use of information labour, but because of the relative lag of productivity of information intensive processes – i.e. asymptotic stagnancy by occupation. If information intensive activities are generally those whose productivity grows most slowly, such a scenario will not be rare. Alternatively, it may be the case that increased demand for information does not take the form of inter-industry purchases (such as increased demand for legal advice) but of increased use of information labour in *all* activities, *within* a given industry.

Unfortunately unavailability of the requisite date prevents us from subdividing the input substitution component into its information demand and asymptotic stagnancy portions. In much of the following discussion we will treat it as though it were made up entirely of the latter – in part because we can offer readers a clear explanation of the asymptotic stagnancy argument (see Ch. 1). We leave to subsequent work the task of providing a clear explanation of the rise in information employment through growing complexity and sophistication of the production process.

2. Growth of the Information Sector 1960-1980

We begin with an evaluation of aggregate growth in information employment. The basic data come from the 1960, 1970, and 1980 decennial censuses in the U.S. The tables of raw occupation by industry for each year were first aggregated, in conformity with a relatively consistent classification scheme, into 267 occupations and 64 industries (see the Appendix for details). The occupations have been grouped further into six categories: (i) knowledge, (ii) data, (iii) services, (iv) goods, (v) a hybrid class including both knowledge and data functions, and (vi) a hybrid class including both data and service functions. We then somewhat arbitrarily split the hybrid knowledge-data category half into knowledge workers and half into data workers and, in similar fashion, split the hybrid data/service category half into data and half into service workers. The resulting groups are referred to as "total knowledge", "total data", and "total service" categories. Information workers are then defined as the sum of (total) knowledge and (total) data workers. The non-information category is composed of the residual, including (total) service and goods workers.[1]

A word should be said about the classification criteria. Professional and technical workers have generally been classified as knowledge or data workers, depending on whether they are producers or users of knowledge. The line is perhaps more than a bit arbitrary at points, and some judgement calls have been made. Moreover, in some cases, professional workers have been classified as data-service workers. This was done with doctors and nurses, since they both use information and perform a personal service. Management personnel have been classified as performing a dual data and knowledge function, since their tasks involve both the production of new information for administrative decisions and the use and transmission of this information. Clerical workers are classified as data workers for obvious reasons. We have classified as goods workers all labour that transforms or operates on materials or physical objects. These include craft workers, operatives (including transportation workers who move physical goods), and unskilled labour. The remaining group is the service workers, who, primarily, perform personal services.

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[1] We also split these groups using other ratios. However, the major results concerning the growth of employment of knowledge and data workers and of the information sector are quite insensitive to the proportions in which we split the two hybrid groups into their constituent parts.

Table 1 gives a breakdown of total absolute employment by type of worker while Table 2 reports the pertinent percentages. Over the two decades, from 1960 to 1980, knowledge workers were the fastest growing group, at 3.5 percent per year (line 8), followed by data workers at 3.1 percent per year (line 9), and service workers (including the allocated portion from the mixed data/service category), at 2.6 percent per year. In contrast, goods producers increased their number at only 0.4 percent per year (line 6). Altogether, employment of information workers grew at 3.2 percent per year, about one percentage point above average, while non-information workers increased at 1.1 percent per year, a point below average.

Table 1
Growth in Total Employment of Information Workers, 1960-1980

		Total Employment (1,000s)			Annual Rate of Growth (Percentage)		
Type of Worker		1960	1970	1980	1960-70	1970-80	1960-80
1.	Knowledge	1,951	3,294	4,821	5.24	3.81	4.52
2.	Data	19,399	26,214	35,861	3.01	3.13	3.07
3.	Knowledge/Data	4,893	5,216	8,044	0.64	4.33	2.49
4.	Data/Services	1,950	2,735	4,796	3.38	5.62	4.50
5.	Services	8,266	9,830	13,250	1.73	2.99	2.36
6.	Goods	28,056	27,010	30,596	-0.38	1.25	0.43
7.	Totals	64,515	74,299	97,369	1.41	2.70	2.06
MEMO (see note)							
8.	**Total Knowledge**	4,398	5,902	8,843	2.94	4.04	3.49
9.	**Total Data**	22,821	30,189	42,282	2.80	3.37	3.08
10.	**Total Information**	27,218	36,091	51,125	2.82	3.48	3.15
11.	**Total Non-Information**	37,297	38,208	46,244	0.24	1.91	1.08

Note: **The total for knowledge workers (line 8) is defined as the sum of line 1 and half of line 3. The total for data workers (line 9) is defined as the sum of line 2, half of line 3, and half of line 4. The total for information workers (line 10) is defined as the sum of line 8 and line 9. The total for non-information workers is the residual.**

We can also discuss the developments by decade. In the first of our two decades, that between 1960 and 1970, total employment grew at 1.4 percent per year. Over the same period, the number of knowledge workers grew by 2.9 percent per year, twice the average rate, and the employment of data workers grew at 2.8 percent per year. The number of service workers increased at 1.9 percent per year, slightly above the average rate, while the employment of goods producers actually declined, even in absolute terms. The total number of knowledge and data workers (line 10) increased by 2.8 percent per year, almost twice the overall rate of growth of employment, while the employment of service and goods employees remained almost unchanged in number between 1960 and 1970.

In the second decade in our tables, that between 1970 and 1980, total employment in the U.S. grew at 2.7 percent per year. Knowledge workers were again the fastest growing group, and in this period they increased 4.0 percent per year. Employment of data workers rose at 3.4 percent per year, less rapidly than that of knowledge workers. Service workers increased their number at 3.3 percent per year, over half a point above average, while the employment of goods workers grew 1.5 percentage points more slowly than average. All told, information workers rose in number at 3.5 percent per year, while the employment of non-information workers increased by 1.9 percent per annum.

Table 2 provides another angle for viewing the growth of the information sector. In 1960, 7 percent of total employment consisted of knowledge workers and 35 percent of data workers. Altogether, 42 percent of the employed labour force were information workers and 58 percent non-information workers. Between 1960 and 1970, the share of knowledge workers in total employment increased by 17 percent, to almost 8 percent. Over the same period, the share of data workers in the employed labour force rose from 35 to almost 41 percent, or by over an eighth. Together, the share of information workers increased to 49 percent, or by one sixth. By 1980, the proportion of information workers in total employment increased to over half. Knowledge workers rose to 9 percent of total employment, while data workers grew to 43 percent.

In sum, during the 1960s, the number of knowledge workers grew fastest, the number of data workers slightly less rapidly, the employment of service workers much more slowly but still above average, while the number of workers employed in goods production declined both in relative and absolute terms. During the 1970s the rank order in growth rates among the four groups of workers remained unchanged, but the difference in the growth rates in number of knowledge and data workers widened considerably, that between data and service workers virtually vanished, while goods workers declined only in relative terms.

Table 2
Percentage Composition of Employment by Type of Worker, 1960-1980

Type of Worker	Percent Distribution 1960	1970	1980	Percentage Change 1960-70	1970-80	1960-80
1. Total Knowledge	6.8%	7.9%	9.1%	16.5%	14.3%	33.2%
2. Total Data	35.4	40.6	43.4	14.9%	6.9%	22.8%
3. Total Services	14.3	15.1	16.1	5.2%	6.6%	12.2%
4. Goods	43.5	36.4	31.4	-16.4%	-13.6%	-27.7%
5. Totals	100.0	100.0	100.0	0.0%	0.0%	0.0%
MEMO						
6. Total Information	42.2	48.6	52.5	15.1%	8.1%	24.5%
7. Total Non-Information	57.8	51.4	47.5	-11.0%	-7.6%	-17.8%

See note to Table 1 for details.

3. Breakdown by Industry and Sector

Since our subsequent analysis depends substantially on comparative shifts in share of information workers among industries it is appropriate to pause to examine what the data show on this matter.

Table 3 reports the percent of information workers in the labour force of each of the major industrial groups. It is instructive, first, to consider the relative information-intensity of the various sectors. The finance, insurance, and real estate sector is the most information-intensive, with about 90 percent of its employees being knowledge or data workers. The trade, services, and government sectors are next in line, with between 45 and 70 percent of their employees in information occupations. In mining, construction, manufacturing, and transportation, information workers comprise between 20 and 45 percent of total employment. Agriculture is the least information-intensive, with under 10 percent of its employees in information jobs.

Table 3
Knowledge and Data Workers as a Percent of Employment by Major Industry Group

	1960			1970			1980		
	Knowledge Workers	Data Workers	Information Workers	Knowledge Workers	Data Workers	Information Workers	Knowledge Workers	Data Workers	Information Workers
1. Agriculture	0.8%	1.4%	2.3%	2.2%	4.1%	6.3%	3.2%	6.4%	9.6%
2. Mining	6.4	18.4	24.8	8.7	24.8	33.4	10.6	28.3	38.9
3. Construction	6.9	12.6	19.4	7.0	17.3	24.3	7.1	20.3	27.4
4. Non-Durable Manufacturing	5.3	22.7	28.0	6.7	26.5	33.2	7.3	28.5	35.8
5. Durable Manufacturing	7.2	24.8	32.0	9.9	27.0	36.8	10.1	28.0	38.2
6. Transportation	5.8	32.7	38.6	6.9	36.6	43.5	8.5	38.2	46.6
7. Trade	7.5	54.9	62.4	6.5	53.0	59.5	8.8	52.1	60.9
8. Finance, Insurance and Real Estate	8.7	81.0	89.6	8.5	82.4	90.9	8.4	83.0	91.4
9. Services	8.4	37.9	46.2	9.4	45.7	55.1	10.2	48.7	58.9
10. Government	8.7	57.2	65.9	10.7	56.1	66.8	11.7	55.0	66.7
Totals	6.8	35.4	42.2	7.9	40.6	48.6	9.1	43.4	52.5

What about trends? Between 1960 and 1970, knowledge workers increased as a proportion of total employment in all sectors except two, trade and finance, insurance, and real estate, while during the 1970s they increased relatively in all sectors except one, finance, insurance and real estate, where they remained virtually constant as a proportion of industry employment. In most sectors, the relative growth in employment of knowledge workers was maintained over the two decades. Between 1960 and 1980, data workers increased relative to total employment in all industries except trade and the government sectors, where they declined slightly in percentage terms. However, the relative gains were greater in the 1960s than in the 1970s. All told, information workers increased in number relative to non-information workers in all sectors except trade over the two decades. Thus, the growth in the information sector was widespread in the economy.

Table 4 examines the same phenomena, this time aggregating *industries* into the three groups: goods, services, and information.[2] In the table, mixed sectors have been split equally into their component parts (the government sector is split in thirds among the goods, services, and information sectors). The percentage of knowledge workers in sectoral employment is greater in the information sector than the service sector and greater in the latter than in the goods-producing industries, though the differences among these groups is not very large, particularly in 1980. It increased in all three sectors between 1960 and 1970 and then again between 1970 and 1980, suggesting substitution of knowledge workers for non-information workers over this period. The percentage of data workers (classified by occupation) in sectoral employment was significantly greater in the information sector than the service sector, and moderately greater in the service sector than the goods sector. The share of data workers grew rather significantly in both the goods and service sectors during the 1960s and also, though more slowly, during the 1970s, suggesting the substitution of data workers for non-information labour. However, in the information sector itself, data workers remained almost unchanged as a share of sectoral employment over the two decades.[3]

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[2] A word should be said about the classification scheme (see the Appendix for the details of the classification). Agriculture, mining, construction, manufacturing, and utilities have been classified as goods industries. Telecommunications, broadcasting, trade, finance, insurance, real estate, education, professional services, and postal services have all been classified as information sectors, since much of their activity can be interpreted as production or distribution of information. Medical services and the business and personal services have been classified as mixed information-service sectors, since they each perform a combination of these functions. The government sector has been categorized as a mixture of all three functions, since they provide both goods and services and engage in information tasks as well.

[3] There is, perhaps, a third pertinent category made up of "information equipment," such as radios, TVs, file cabinets, and computers, with this category distinguished from non-information equipment and material output. Such an approach is followed by Staglin [1986]. As the author notes, this distinction appears to confuse the inputs of information activities, such as paper, with information output, such as the contents of books. It appears more helpful to maintain the distinction between information and non-information output and classify all inputs in information sectors as directly or indirectly embodied in information output. See below.

Table 4
Knowledge and Data Workers as a Percent of Employment in the Goods, Services and Information Sector

	1960			1970			1980		
	Knowledge Workers	Data Workers	Information Workers	Knowledge Workers	Data Workers	Information Workers	Knowledge Workers	Data Workers	Information Workers
1. Goods	5.5%	20.1%	25.6%	7.4%	24.6%	31.9%	7.9%	26.8%	34.7%
2. Services	6.0	27.3	33.3	6.8	33.4	40.2	8.4	38.4	46.8
3. Information	8.6	56.2	64.8	8.8	57.4	66.2	10.2	58.0	68.1
Totals	6.8	35.4	42.2	7.9	40.6	48.6	9.1	43.4	52.5

Note: See the text and Appendix for details on sectoral classifications.

4. Hypotheses about the Trends

How can one explain these trends? One obvious hypothesis is that the increasing sophistication and complexity of our productive mechanism requires even more information for its "interstitial" adjustments, or that an increasingly educated population demands products with even greater information content. However, an alternative line of explanation is also available.

The model of unbalanced growth shows that *with constant output proportions*, employment in industries with relatively slower rates of productivity growth must increase relative to employment in high productivity growth industries. The model of asymptotic stagnancy applies the logic of the unbalanced growth model *to input activities* which use in fixed proportions some inputs whose production is progressive and some which are stagnant in terms of labour productivity growth. An example is the computer service industry, which uses as inputs computer hardware, whose production is technically progressive and computer software, an input produced by an asymptotically stagnant process, involving some data manipulation (in which labour productivity is increasing, since high level languages can now write the detailed code which used to be written line by line) and some knowledge production (since someone must still write the programme, even in a high level language). Given these differences in growth rates of labour productivity in the computer service industry, the activity with slowest productivity growth (i.e. programming) will grow in relative employment within the activity of software production, which will grow in relative importance compared to hardware production.

If the progressive and stagnant inputs are used in fixed proportions in real terms, the labour employed in producing the stagnant component will increase relative to the employment in the progressive component. Both models are based on the same logic of a relative increase of employment of workers engaged in relatively stagnant activities, if output or input proportions stay relatively fixed. However, to keep the issue clear we refer to the "interindustry effect" we see when we discuss differential growth rates in employment by industry and "asymptotic stagnancy" when we refer to trends in the occupational composition of employment within industries.

Of the four classes of workers in our classification scheme, we see the activity of knowledge workers as the most stagnant, technologically, in the sense that the production of knowledge is itself an activity that is not readily amenable to technical change. The activity of data workers would seem to be more progressive than that of knowledge workers, since part of their task involves the acquisition and transmission of information, which do benefit from technological advance (through computers, new telecommunication equipment and the like). However, the portion of their activity that involves the analysis and comprehension of information (reading, for example) seems much more difficult to change technologically. The activity of personal service workers is, again, technologically stagnant. Finally, the activity of goods workers, as a group, is the most progressive, since goods production is amenable to the substitution of capital for labour.

The relative decline in number of goods workers over the period and the corresponding increase in knowledge, data, and service workers can, thus, conceivably be explained by the model of unbalanced growth by industry, combined with asymptotic stagnancy within industries. The increase in number of knowledge workers relative to service and goods workers during the 1960s and relative to the other three categories of labour during the 1970s is also consistent with the model. However, the explanation offered by the model is imperfect since it does not account in any obvious way for the fact that the employment of knowledge workers and data workers both increased at about the same rate during the 1960s, while that of data and service workers grew proportionately during the 1970s.

There are several possible explanations. First, output proportions are not fixed over time. Second, in industries in which there are both a progressive and stagnant input component, the proportion between the input activity levels may change over time. Third, the assumption that knowledge activities are relatively more stagnant than data activities is a maintained hypothesis of this model, which needs further examination. Obviously, the influence of unbalanced growth in productivity needs to be tested with the aid of more powerful tools, a task to which we turn in the next section.

We will proceed by trying to divide the observed changes in the shares of different types of employment into several components: roughly into those associated with an increase in demand for information services, those corresponding to an increase in demand for information services within the production process, and those that can be ascribed to a shift in employment due to lag in productivity growth of the relatively (in terms of productivity) stagnant information activities.

5. Decomposition of Employment Change

Let us begin by defining the following matrix and vector components:

X = column vector showing the total output (gross domestic output or GDO) by sector;

Y = column vector showing the final output by sector;

M = the employment matrix, where M_{ij} shows the total employment of occupation i in industry j;

L = a row vector showing total employment in industry j, where $L_j = \sum_i M_{ij}$;

B = a column vector of total employment by occupation, where $B_i = \sum_i M_{ij}$.

Let us now define the following coefficients:

a = square matrix of interindustry input-output coefficients where a_{ij} indicates the amount of input i required per unit of output j.

y = a column vector showing the percentage distribution of final output by sector, where $y_i = Y_i / \Sigma Y_i$;

n = an employment distribution matrix, showing the percentage distribution of employment by occupation within each sector, where $n_{ij} = M_{ij}/L_j$;

m = the employment coefficient matrix, showing employment by occupation per unit of output, where $m_{ij} = M_{ij}/X_j$;

p = a row vector showing the percentage distribution of employment by sector, where $p_j = L_j/\Sigma L_j$;

ℓ = a row vector of labour coefficients showing total employment per unit of output, where $\ell_j = L_j/X_j$;

b = a column vector showing the percentage distribution of employment by occupation, where $b_i = B_i/\Sigma B_i$.

To derive our basic tautological relationship, we first express the matrix of occupational output-employment coefficients, m, in terms of the vector of industry coefficients, ℓ, obtaining

$$m = n\ell_d, \tag{4}$$

where a subscript d connotes a diagonal matrix whose elements are those of the associated vector (ℓ). It follows from the basic Leontief identity, $X = (I\text{-}a)^{-1}Y$, and (4) that

$$b^* = m(I\text{-}a)^{-1}y \tag{5}$$

where b^* is the distribution of employment by occupation generated by the percentage output vector y. Then by (4) and (5)

$$b^* = n\,\lambda_d y.$$

where $\lambda = \ell(I\text{-}a)^{-1}$ and λ_i shows the direct plus indirect labour requirements per unit of output $_i$.

We have, directly,

$$\Delta b(y) = \Delta n\lambda_d y + n(\Delta\lambda_d)\,y + n\lambda_d y] / \Sigma b^*, \tag{6}$$

where b(y) is the percentage distribution of employment generated by the output vector y. This equation, then, decomposes a change in occupational composition of employment $\Delta b(y)$, into three parts:

(i) $\Delta n\lambda_d y/\Sigma b^*$, which corresponds to the change in the n_{ij}, the shares of the different occupations, by industry. In other words, this term reflects, in part, the extent to which production processes within industries have changed their techniques so as to substitute information labour for labour of other types. However, as we saw earlier, this term also reflects in part any relative growth in productivity of non-information labour which tends automatically to depress the relative demand for such labour within industries – another variant of the productivity lag effect. We will call this term in the equation the *production substitution component*;

(ii) the second term in (6) involves $\Delta\lambda_d$ the change in the vector of quantities of direct and indirect labour per unit of output, by industry; i.e., the change in the reciprocal of each industry's "total" labour productivity. We call this the *productivity lag component*;[4]

(iii) the final term involving the incremental change, Δy, in the shares of the total outputs of the different industries, we describe as the *(final) output shift component*.

Thus, if the last term turns out to be significant and substantial in an empirical calculation, this will imply that the growth in information employment is indeed attributable to an information revolution. For a large third term indicates that buyers are typically turning increasingly to outputs whose production has a large information content. The same may also be true, in part, of a large first term, which may indicate that a typical production process has increased its reliance on information labour. However, if the second term turns out to be substantial and significant it will suggest that a corresponding portion of the increase in share of information labour is attributable not to an upsurge in information use, but rather to unbalanced growth – the shift of labour out of industries whose productivity growth is atypically large.

The results derived from this decomposition are shown in Table 5.[5] It contains three panels. The first shows the contribution of each of the four components in terms of percentage point change in the share of each occupational group. The second shows what proportion of the change in the share of each group is accounted for by each component. The third panel shows what the annual percentage growth rate of each occupational group would have resulted from each component if total employment (L) had been fixed. To show how to interpret this table, let us consider as an example the change in share of the knowledge workers (the *producers* of information) in total employment during the

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[4] The second term can be further decomposed into two effects: one emanating from a change in the direct labour coefficients and the other from a change in the structure of interindustry coefficients. The results indicated that the added effect from the change in the interindustry coefficient structure was not very important.

[5] See the Appendix for a description of the occupational matrices. The sectoral output and productivity indices are based on 155-sector gross output figures in 1972 dollars and hours worked by employed persons. These data were obtained on tape from the Bureau of Labour Statistics (BLS). The BLS data were aggregated to the 64-sector industry classification scheme shown in the Appendix, and the occupation by industry matrices were aligned to the BLS total hours figures. Estimates of the decomposition shown in equation (6) were based on three sets of weights: beginning of the period, end of the period, and average period shares. The results were quite insensitive to the choice of weights, and only results based on average period weights are shown.

Table 5
Summary Table: Decomposition of the Change in Employment Composition Into a Production Substitution, Productivity Lag, and Final Output Shift Effect

Type of Worker	Decomposition of Change in Employment Composition (percentage points)				Percentage Decomposition of change in Employment Composition				Annual Percentage Rate of Growth of Employment (Assuming total employment fixed)			
	Subst. Effect	Prod. Lag Effect	Output Effect	Total Change	Subst. Effect	Prod. Lag Effect	Output Effect	Total Change	Subst. Effect	Prod. Lag Effect	Output Effect	Total Change
1. 1960-70 Period												
1. Total Knowledge	0.78	0.36	-0.22	1.13	69.6%	-32.3%	-1.9%	100.0%	1.09%	0.42%	0.02%	1.53%
2. Total Data	2.06	2.69	0.51	5.26	39.1	51.2	9.6	100.0	0.57	0.74	0.08	1.39
3. Total Services	0.06	0.73	-0.05	0.75	7.8	-98.3	-6.1	100.0	0.04	0.48	-0.02	0.51
4. Goods	-2.94	-4.00	-0.19	-7.13	41.3	-56.1	2.6	100.0	-0.70	-1.00	-0.09	-1.79
Total Information	3.01	3.01	0.36	6.39	47.2	-47.2	5.6	100.0	0.69	0.68	0.04	1.41
2. 1970-80 Period												
1. Total Knowledge	0.96	0.52	-0.34	1.14	84.1	45.3	-29.5	100.0	1.14	0.45	-0.25	1.34
2. Total Data	1.40	0.78	0.62	2.79	50.1	27.8	22.2	100.0	0.34	0.18	0.15	0.66
3. Total Services	-0.08	0.99	0.09	1.00	-7.8	99.2	8.7	100.0	-0.05	0.65	0.05	0.64
4. Goods	-2.42	-1.99	-0.52	-4.93	49.0	40.4	10.6	100.0	-0.69	-0.61	-0.16	-1.46
Total Information	2.40	1.04	0.49	3.93	61.0	26.6	12.4	100.0	0.48	0.19	0.11	0.78
3. 1960-80 Period												
1. Total Knowledge	1.74	0.67	-0.15	2.27	76.9	29.6	-6.5	100.0	1.14	0.18	0.12	1.43
2. Total Data	3.51	3.28	1.26	8.05	43.5	40.8	15.7	100.0	0.47	0.43	0.13	1.03
3. Total Services	0.02	1.65	0.08	1.75	1.3	94.3	4.4	100.0	0.01	0.54	0.03	0.58
4. Goods	-5.41	-5.76	-0.90	-12.06	44.8	47.7	7.4	100.0	-0.66	-0.79	-0.17	-1.62
Total Information	5.49	3.90	0.93	10.32	53.2	37.8	9.0	100.0	0.61	0.39	0.09	1.09

Note: Average period weights are used in all cases. The production substitution, productivity lag, and gross output shift effects are derived from equation (6) in the text.

first subperiod of our study. According to the first line in the left-hand panel of the table, this share increased by 1.13 percentage points in that 1960-70 decade. Of this, the production substitution component is reported to have accounted for 0.78 percentage points (first panel) or 70 percent of the total change (second panel). If total employment had been fixed, knowledge workers would have grown at a rate of 1.09 percent per year over this period because of the production substitution component alone (third panel).

Before discussing the details let us see what overall results are shown by the table. Its last line summarizes what happened to the share of all information workers (i.e., knowledge plus data workers) over the entire twenty-year period. We see that this share grew by 10.3 percentage points (panel 1). Some 53 percent of this change was made up of its production substitution component, 38 percent was due to the productivity lag component (panel 2, last line), while the shift in the composition of final output contributed only 9 percent.

In sum, on the production side of the economy, a large contribution was made by technological change within each industry which substituted information labour for other types of labour. The interindustry productivity lag effect was also quite strong. The absorption of workers from industries whose productivity grew relatively slowly served to increase the share of information workers by a significant amount. The magnitude of these two components together implies that the so-called "information explosion" is primarily a consequence of unbalanced growth, and that the substitution of information labour within production and uneven productivity growth among industries together may have raised the share of information labour in the labour force over 9 percentage points in two decades (panel 1, last line).

In contrast, the role of demand shifts towards heavily information using products (component iii) was very modest. By itself it might perhaps have raised the demand for information labour only 0.1 percent per year, compounded, had total employment in the economy remained constant over the two decades (last panel of the table). In conclusion, the data indicate that, like the so-called "shift to the services," the autonomous growth in demand for information labour was quite minimal.

6. Conclusions by Decade, and Knowledge and Data Worker Categories

Having examined the overall implications of the decomposition calculation, let us turn to some of its details. For this purpose we go back to our subclassification of information workers into knowledge workers (information producers) and data workers (knowledge users).

Let us begin with the knowledge worker subgroup. As we saw in our introductory discussion of the top row of Table 5, the most important factor in the relative growth of knowledge workers over the 1960s and 1970s was the substitution of knowledge workers for other classes of workers within industries. This effect accounted for 70 percent of their relative growth over the 1960s and 84 percent over the 1970s.

Productivity growth in knowledge-intensive industries was relatively low over the two decades and served to increase the employment of knowledge workers. During the 1960s, the relatively high productivity growth in this sector accounted for a 0.36 percentage increase in the employment of knowledge workers, while during the 1970s it accounted for a 0.52 percentage point rise. The productivity lag effect was about half as strong as the substitution effect in each of the two decades.

The shift in output demand toward knowledge-intensive products was of negligible importance during the 1960s, while during the 1970s it actually served to depress the demand for knowledge workers. Over the two decades, the substitution effect accounted for about three-fourths of relative employment growth of the knowledge workers, and the interindustry productivity lag effect the other quarter.

Let us turn next to the data workers (second row in each section of Table 5). Almost 40 percent of the increase in their relative share during the 1960s is attributed by the calculation to the substitution of data workers for other workers within industries. As in the knowledge-intensive industries, productivity growth was slower than average in data-intensive industries, and about half of the growth in employment of data workers is attributable to the relatively slower productivity growth of these sectors. The shift in demand toward data-intensive output was of minor importance during this period. During the 1970s,the production substitution effect was the dominant element, accounting for half of the increase in the share of data workers, while the interindustry productivity lag component accounted for 28 percent. During the 1970s, there was a significant shift in demand toward data-intensive output, and this accounted for 22 percent of the employment growth of this period.

Next, consider the share of service workers. For them, as shown in previous studies, the interindustry productivity lag effect was dominant, accounting for almost all of their employment growth during the two decades. The relatively slower productivity growth of service-intensive sectors served to increase service workers' employment share in the two decades by 1.7 percentage points. Both the substitution of industry employment away from service workers and shifts in final output composition had a negligible impact on their relative employment. Finally, turning to goods workers, the two unbalanced growth effects together accounted for almost all of the relative decline in their employment share. During the 1960s, over 40 percent of the relative decline in the employment of goods workers was accounted for by the substitution of other workers for goods producers within industries and over 40 percent by the relatively *higher* rate of productivity growth of the goods-producing sectors. During the 1970s, the magnitudes of the two effects remained virtually unchanged. The shift in output demand was again of relatively minor importance in the two decades, accounting for only three percent of the relative decline in the employment of goods producers during the first decade and 11 percent during the second.

In summary, the two dominant elements in the composition of employment were the production substitution and interindustry productivity lag components. Shifts in the composition of output were a relatively minor element, though the output composition effect grew in importance over the two decades. For knowledge workers, the substitution of workers within industry production was twice as important as unbalanced growth between industries. For both data and goods workers, the two effects were of almost equal magnitude. On the other hand, relative productivity movements between industries were by far the dominant element in explaining the relative growth of service workers.

Finally, the third panel of Table 5 exhibits another relationship that seems consistent with the expectations that might have been stimulated by the asymptotic stagnancy model. To the extent that the logic of this model underlies the behaviour of the production substitution component, we should expect, in terms of that component alone, that employment of knowledge workers would grow fastest, that of data workers second fastest, service workers third, and goods workers slowest, since that is what we might expect their rankings in terms of productivity growth to be. This turns out to have been true in both the 1960s and the 1970s. Moreover, service workers grew faster than total employment during the two decades while goods workers grew less slowly than total employment, as the model would predict.

The model of unbalanced growth between industries also suggests that relative productivity movements should lead the body of knowledge workers to grow most rapidly, data and service workers less rapidly but faster than total employment, and the number of goods workers least rapidly. This is what happened over the two decades, except for the important exception of knowledge workers. We shall discuss some of the possible reasons for this finding below. Finally, the output shift effect was positive for knowledge, data, and service workers, and negative for goods workers. The relative magnitude of this effect varied over the two decades. However, over the 20-year period, the effect was strongest for knowledge and data workers, ranked second (and almost zero) for service workers, and ranked last (and negative) for service workers. These results indicate a slight shift in demand toward information-intensive output.

7. Conclusion

This paper documents once again the rapid growth of information workers in both absolute and relative terms in the U.S. economy over the period from 1960 to 1980. In terms of our classification over these years, knowledge workers (those who produce information) grew from 6.8 to 9.1 percent of total employment, data workers (those whose job is to use information) grew from 36 to 43 percent, and information workers as a body from 42 to 53 percent. These results are consistent with those of other studies.

The novel result of the work reported here is the evidence that the rising share of the labour force in information related occupations is the result of two distinct forces, both of which may be considered the ingredients of unbalanced growth. The first,and more important factor, is the substitution of information workers, particularly knowledge producers, for non-information workers within production. This factor accounted for over half of the increase in the share of information employees in total employment. The second is relative productivity movements among industries, which accounted for over a third of the relative growth of information workers and over 40 percent of the relative growth of data workers. We also find that the shift in demand toward information-intensive output was of relatively minor importance, accounting for only 9 percent of the growth in information employment, though 16 percent of the growth in data workers.

The one apparent anomaly in our results is that, contrary to expectations, low productivity growth in knowledge-intensive industries did not play a large role in the relative increase in knowledge workers over the two decades. Yet, on second thought, this result may not be too surprising, since productivity growth in an industry can be stimulated by the employment of a large number of knowledge workers. Indeed, research on the sources of productivity growth have consistently found a large positive effect of the number of knowledge workers on an industry's rate of technological progress. Thus, even though knowledge production may itself be a stagnant activity, it may nonetheless contribute strongly to productivity growth in industries in which the activity is located.

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Appendix

Classification of Industries

No.	Industry Name	1970 Census Code	Classification
1	Agriculture, Forestry, Fisheries	017-029	Goods
2	Metal Mining	047	Goods
3	Coal Mining	048	Goods
4	Crude Petro and Natural Gas Refining	049	Goods
5	Nonmetalic Mining, Quarrying, except Fuel	057,058	Goods
6	Construction	067-078	Goods
7	Meat and Dairy	268,269	Goods
8	Grain Mill Products	279	Goods
9	Beverage Industries	289	Goods
10	Canning, Bakery, Confectionary, Other	278,287,288,297,298	Goods
11	Tobacco Manufactures	299	Goods
12	Textile Mill, Fabricated Textile Products	307-318,327	Goods
13	Apparel	319	Goods
14	Logging	107	Goods
15	Wood Products except Furniture	108,109	Goods
16	Furniture and Fixtures	118	Goods
17	Paper and Allied Products	328-337	Goods
18	Printing, Publishing, Allied Industries	338,339	Goods
19	Chemicals	347-349,358,367-369	Goods
20	Drugs and Medicines	357	Goods
21	Paints, Varnishes, Related Products	359	Goods
22	Petroleum and Coal Products	377,378	Goods
23	Rubber, Misc. Plastic Products	379,387	Goods
24	Leather and Leather Products	388-397	Goods
25	Glass, Glass Products	119	Goods
26	Cement, Concrete, Gypsum, Plaster Products	127	Goods
27	Structural Clay and Pottery Products	128,137	Goods
28	Misc. Nonmetallic Mineral, Stone Products	138	Goods
29	Steel and Iron Industries	139,147	Goods
30	Nonferrous Metals	148-149	Goods
31	Cutlery, Hand Tools, Other Hardware	157	Goods
32	Fabricated Metal, including Ordinance	158-169,258	Goods
33	Farm Machinery and Equipment	178	Goods
34	Computers, Office Equipment	188,189	Goods
35	Machinery, NEC except Electrical	177,179,187,197,198	Goods

Classification of Industries (cont'd)

No.	Industry Name	1970 Census Code	Classification
36	Electrical Machinery, Equipment, Supplies	199-209	Goods
37	Motor Vehicles and Equipment	219	Goods
38	Aircraft and Parts	227	Goods
39	Ship, Boat Building and Repair	228	Goods
40	Other Transportation Equipment	229,237,238	Goods
41	Professional, Photo Equip, Watches	239-257	Goods
42	Miscellaneous Manufacturing	259,398	Goods
43	Transportation	407-429	Goods
44	Telephone, Telegraph and Misc. Comm.	448,449	Information
45	Radio Broadcasting and TV	447	Information
46	Utilities	467-479	Goods
47	Wholesale Trade	507-599	Information
48	Retail Trade	607-699	Information
49	Banking, Credit, Investment Companies	707-709	Information
50	Insurance	717	Information
51	Real Estate incl. Insur. and Law Offices	718	Information
52	Hotel, Motels and Lodging Places	777,778	Goods/Services
53	Barber, Beauty Shops	787,788	Services
54	Advertising	727	Information
55	Auto Services and Repair	749,757	Goods/Services
56	Amusements	807-817	Information/ Services
57	Medical Services	828-837, 839-848	Information/ Services
58	Hospitals	838	Information
59	Education Services	857-868	Information
60	Professional Services, NEC	849,888-897	Information
61	Nonprofit Organizations	869-887	Information/ Services
62	Business and Personal Services, NEC	728-748,758-767,769, 779,789-799	Information/ Services
63	Postal Services	907	Information
64	Public Administration; Fed., State, Local	917,927,937	Information/ Services/ Goods

Classification of Occupations

No.	Occupation Name	1970 Census Code	Classification
1	Accountants	001	Data
2	Architects	002	Knowledge
3	Computer Programmer	003	Knowledge
4	Computer Systems Analyst	004	Knowledge
5	Computer Specialists, NEC	005	Knowledge
6	Aero- and Astronautical Eng.	006	Knowledge
7	Chemical Engineer	010	Knowledge
8	Civil Engineer	011	Knowledge
9	Electrical and Electronic Eng.	012	Knowledge
10	Industrial Engineer	013	Knowledge
11	Mechanical Engineer	014	Knowledge
12	Metal, Material, Mining and Petro Eng	015,020,021	Knowledge
13	Sales Engineers	022	Data
14	Engineers, NEC	023	Knowledge
15	Farm Management, Advisors, Forestors, Conservationists and Home Mgmt Adv.	024-026	Knowledge
16	Judges	030	Knowledge
17	Lawyers	031	Data
18	Librarian, Archivist, Curator	032,033	Data
19	Actuary, Statistician, O.R. Analyst	034,036,055	Knowledge
20	Mathematician	035	Knowledge
21	Agricultural Scientists	042	Knowledge
22	Biological Scientists	044	Knowledge
23	Chemists	045	Knowledge
24	Geologists, Physicists, Astronomers	051,053	Knowledge
25	Life and Physical Scientists, NEC	043,052,054	Knowledge
26	Personnel and Labor Relations Wkrs	056	Data/Service
27	Chiropractors	061	Data/Service
28	Dentists	062	Data/Service
29	Optometrists	063	Data/Service
30	Pharmacists	064	Data
31	Physicians, Med and Osteopathic	065	Data/Service
32	Veterinarians	072	Data/Service
33	Podiatrists, Health Practitioners, NEC	071,073	Data/Service
34	Dietitians	074	Data/Service
35	Registered Nurse	075	Data/Service
36	Therapists	076	Data/Service

Classification of Occupations (cont'd)

No.	Occupation Name	1970 Census Code	Classification
37	Health Technologists and Technicians	080-085,426	Data
38	Clergymen	086	Data/Service
39	Religious Workers, NEC	090	Data/Service
40	Social Scientists	091-096	Knowledge
41	Social Workers	100	Data/Service
42	Recreation Workers	101	Data
43	Teachers. College and University	102-140	Knowledge
44	Adult Education Teachers	141	Data
45	Elementary and Secondary Teachers	142,144	Data
46	Pre- and Kindergarten Teachers	143	Data
47	Teachers, Exc. College and Univ., NEC	145	Data
48	Agricultural, Biol., Chem. Technicians	150,151	Data
49	Draftsmen	152	Data
50	Electrical Engineering Technicians	153	Data
51	Engineering and Science Technicians, NEC	154-162	Data
52	Airplane Pilot	163	Data/Goods
53	Air Traffic Controller	164	Data
54	Flight Engineer	170	Data
55	Tool Programmer, Numerical Control	172	Data
56	Technicians, Nec Including Radio Operator	171, 173	Data
57	Vocational and Educational Counselors	174	Data/Service
58	Designer	183	Knowledge
59	Editors and Reporters	184	Knowledge
60	Writers, Artists, Entertainers, Nec	175-182, 185-194	Knowledge
61	Research Worker, Not Specified	195	Knowledge
62	Bank Officers & Financial Managers	201, 202	Knowledge/Data
63	Buyers & Shippers: Farm, Wholesale, Retail	203, 205	Data
64	Credit Men	210	Data
65	Funeral Directors & Embalmers	211, 165	Data/Service
66	Health Administration	212	Knowledge/Data
67	Construction Inspectors, Public Health	213	Data
68	Inspectors, Exc. Construction, Pub Admin	215	Data
69	Managers & Superintendents, Building	216	Data/Service
70	Office Managers, NEC	220	Data
71	Officers, Pilots, Pursers; Ship	221	Knowledge/Data
72	Administrators, Public Admin, NEC	222	Knowledge/Data

Classification of Occupations (cont'd)

No.	Occupation Name	1970 Census Code	Classification
73	Officials of Lodges, Societies, Unions	223	Knowledge/Data
74	Postmasters and Mail Superintendents	224	Knowledge/Data
75	Purchasing Agents and Buyers, NEC	225	Data
76	Railroad Conductor	226	Data
77	Restaurant, Cafeteria, Bar Manager	230	Data/Service
78	Sales Manager and Dept Heads, Retail	231	Knowledge/Data
79	Sales Managers, Except Retail Trade	233	Knowledge/Data
80	School Admin., College, Element, Secondary	235, 240	Knowledge/Data
81	Managers and Administrators, NEC	245	Knowledge/Data
82	Advertising Agents and Salesmen	260	Data
83	Auctioneers, Demonstrators, Hucksters,	261-264	Data
84	Insurance Agents, Brokers, Underwriters	265	Data
85	Newsboy	266	Data
86	Real Estate Agents and Brokers	270	Data
87	Stock and Bond Salesmen	271	Data
88	Sales Rep. Manufacturing and Wholesale	281, 282	Data
89	Sales Clerk, Retail; Salesmen	283, 284, 285	Data
90	Bank Teller	301	Data
91	Bookkeeper	305	Data
92	Cashiers	310	Data
93	Collectors, Bill and Account	313	Data
94	Dispatchers and Starters, Vehicle	315	Data
95	File Clerk	325	Data
96	Insurance Adjusters and Examiners	326	Data
97	Library Attendants and Assistants	330	Data
98	Mail Carriers, Post Office	331	Data
99	Messengers and Office Boys	333	Data
100	Miscellaneous Clerical Workers	303, 311, 312, 314 320-323, 332, 334, 362, 383, 392-395	Data
101	Office Machine Operators	341-355	Data
102	Payroll and Timekeeping Clerk	360	Data
103	Postal Clerk	361	Data
104	Real Estate Appraiser	363	Data
105	Receptionists	364	Data
106	Secretaries	370-372	Data
107	Shipping and Receiving Clerk	374	Data
108	Statistical Clerk	375	Data

Classification of Occupations (cont'd)

No.	Occupation Name	1970 Census Code	Classification
109	Stenographer	376	Data
110	Stock Clerks and Storekeepers	381	Data
111	Teachers Aides, Except School Monitors	382	Data
112	Telegraph Operators	384	Data
113	Telephone Operator	385	Data
114	Ticket, Station and Express Agent	390	Data
115	Typist	391	Data
116	Bakers	402	Goods
117	Blacksmiths	403	Goods
118	Boilermakers	404	Goods
119	Brick-, Stonemasons, Appr. and Tile Setters	410, 411, 560	Goods
120	Bulldozer, Excavating, Grading Operators	412, 436	Goods
121	Cabinetmakers	413	Goods
122	Carpenters and Apprentices	415, 416	Goods
123	Cement & Concrete Finishers	421	Goods
124	Compositors, Typesetters and Appr.	422, 423	Goods
125	Cranemen, Derrickmen, Hoistmen	424	Goods
126	Decorators and Window Dressers	425	Goods
127	Electricians and Apprentices	430, 431	Goods
128	Electric Power Linemen and Cablemen	433	Goods
129	Electro-, Sterotypes, Engravers	434, 435	Goods
130	Foremen, NEC	441	Data
131	Forgemen and Hammermen	442	Goods
132	Painters	443, 510-512, 543	Goods
133	Glazers	445	Goods
134	Heat Treaters, Annealers, Temperers	446	Goods
135	Inspectors, NEC Including Scalers, Graders	450, 452	Goods
136	Jewelers and Watchmakers	453	Goods
137	Job and Die Setters, Metal	454	Goods
138	Locomotive Engineers and Firemen	455, 456	Goods
139	Machinists and Apprentices	461, 462	Goods
140	AC, Heating, Refrigeration Repairmen	470	Goods
141	Aircraft Mechanic	471	Goods
142	Mechanics and Repairmen, NEC, Machinery	472-481	Goods
143	Household Appliance, Accessory Installers and Mechanics	482	Goods
144	Loom Fixers	483	Goods

Classification of Occupations (cont'd)

No.	Occupation Name	1970 Census Code	Classification
145	Office Machine Mechanics and Repairmen	484	Goods
146	Radio and TV Repairmen	485	Goods
147	Railroad and Car Shop Mechanics	486	Goods
148	Misc. Mechanics and Repairmen	491-495	Goods
149	Millers; Grain, Flour, Feed	501	Goods
150	Millwrights	502	Goods
151	Molders, Metal and Apprentices	503, 504	Goods
152	Motion Picture Projectionists	505	Goods
153	Opticians, Lens Grinders and Polishers	506	Goods
154	Pattern and Model Makers, Except Paper	514	Goods
155	Photoengravers and Lithographers	515	Goods
156	Plasterers and Apprentices	520, 521	Goods
157	Plumbers, Pipe Fitters and Apprentices	522, 523	Goods
158	Power Station Operators	525	Goods
159	Pressmen, Plate Printers, Printing and Apprentices	530, 531	Goods
160	Rollers and Finishers, Metal	533	Goods
161	Roofers and Slaters	534	Goods
162	Sheetmetal Workers, Tinsmiths and Apprentices	535,536	Goods
163	Shipfitters	540	Goods
164	Shoe Repairmen	542	Goods
165	Stationary Engineers	545	Goods
166	Structural Metal Craftsmen	550	Goods
167	Tailors	551	Goods
168	Phone Installers, Repairmen, Linemen, Splicers	552-554	Goods
169	Tool and Die Makers and Apprentices	561,562	Goods
170	Upholsterers	563	Goods
171	Craftsmen and Kindred Workers, NEC	410,405,420,440,444 516, 546, 571-575	Goods Goods
172	Asbestos and Insulation Workers	601	Goods
173	Assemblers	602	Goods
174	Blasters and Powdermen	603	Goods
175	Bottling and Canning Operatives	604	Goods
176	Chainmen, Rodmen, Axmen; Surveying	605	Goods
177	Checkers, Examiners, Inspectors; Manuf.	610	Goods
178	Clothing Ironers and Pressers	611	Goods

Classification of Occupations (cont'd)

No.	Occupation Name	1970 Census Code	Classification
179	Cutting Operatives, NEC	612	Goods
180	Dressmakers, Seamstresses, except Factory	613	Goods
181	Drillers, Earth	614	Goods
182	Dry Wall Installers and Lathers	615	Goods
183	Dyers	620	Goods
184	Filers, Polishers, Sanders, Buffers	621, 651	Goods
185	Furnacemen, Smeltmen, Pourers	622	Goods
186	Garage Workers, Gas Station Attendants	623	Goods
187	Graders and Sorters, Manufacturing	624	Goods
188	Produce Graders Packers, except Factory and Farm	625	Goods
189	Heaters, Metal	626	Goods
190	Laundry, Dry Cleaning Operatives, NEC	630	Goods
191	Meat Cutters and Butchers	631, 633	Goods
192	Packers and Wrappers, except Produce	634, 643	Goods
193	Metal Platers	635	Goods
194	Mine Operatives, NEC	640	Goods
195	Mixing Operatives	641	Goods
196	Oilers and Greasers, except Auto	642	Goods
197	Painters, Manufactured Articles	644	Goods
198	Photographic Process Workers	645	Goods
199	Drill Press Operatives	650	Goods
200	Lathe, Milling Machine Operatives	652	Goods
201	Precision Machine Operatives, NEC	653	Goods
202	Punch and Stamping Press Operatives	656	Goods
203	Riveters and Fasteners	660	Goods
204	Sailors and Deckhands	661	Goods
205	Sawyers	662	Goods
206	Sewers and Stitchers	663	Goods
207	Shoemaking Machine Operatives	664	Goods
208	Solderers	665	Goods
209	Stationary Firemen	666	Goods
210	Carding, Lapping, Combing Operatives	670	Goods
211	Knitters, Loopers, Toppers	671	Goods
212	Spinners, Twisters, winders	672	Goods
213	Weavers	673	Goods
214	Textile Operatives, NEC	674	Goods

Classification of Occupations (cont'd)

No.	Occupation Name	1970 Census Code	Classification
215	Welders and Flame-Cutters	680	Goods
216	Winding Operatives, NEC	681	Goods
217	Machine Operatives, Misc Specified	636, 690	Goods
218	Miscellaneous Operatives	692-695	Goods
219	Transportation Operatives	701-705	Goods
220	Fork Lift, Tow Motor Operatives	710	Goods
221	Motormen; Mine, Factory, Logging Camp, etc.	710	Goods
222	Parking Attendants	711	Goods
223	Railroad Brakemen	712	Goods
224	Railroad Switchmen	713	Goods
225	Taxicab Drivers, Chauffeurs	714	Goods
226	Truck Drivers	715	Goods
227	Animal Caretakers, except Farm	740	Goods
228	Construction Laborers	750, 751	Goods
229	Fishermen and Oystermen	752	Goods
230	Freight and Materials Handlers	753	Goods
231	Garbage Collectors	754	Services
232	Gardeners and Groundskeepers, except Farm	755	Services
233	Longshoremen and Stevedores	760	Goods
234	Lumbermen, Raftsmen, Woodchoppers	761	Goods
235	Stock Handlers	762	Goods
236	Teamsters	763	Goods
237	Vehicle Washers and Equipment Cleaners	764	Goods
238	Warehousemen, NEC	770	Goods
239	Miscellaneous Laborers	780	Goods
240	Not Specified Laborers	785	Goods
241	Farmers: Owners and Tenants; Farm Managers	801, 802	Goods
242	Farm Foreman; Farm Labor	821-824	Goods
243	Cleaning Service Workers	901-903	Services
244	Food Service Workers, exc. Private HH	910, 911, 913, 914, 916	Services
245	Cooks except Private Household	912	Services
246	Waiters	915	Services
247	Health Aides (inc. Dental Asst; Trainees)	921-923	Services
248	Nursing Aides, Orderlies, Attendants	925	Services
249	Practical Nurses, inc. Lay Midwives	924, 926	Services
250	Airline Stewardesses	931	Services
251	Attendants; Recreation, Amusement	932	Services

Classification of Occupations (cont'd)

No.	Occupation Name	1970 Census Code	Classification
252	Attendants, Personal Service, NEC	933, 934	Services
253	Barbers	935	Services
254	Boarding and Lodging House Keepers	940	Services
255	Bootblacks	941	Services
256	Child Care Workers, except Private HH	942	Services
257	Elevator Operators	943	Services
258	Hairdressers, Cosmotologists, Pers. Serv. Appr.	944, 945	Services
259	Housekeepers except Private Household	950	Services
260	School Monitors, Ushers, Recreation and Amusement	952, 953	Services
261	Welfare Service Aides	954	Services
262	Crossing Guards and Bridge Tenders	960	Services
263	Firemen, Fire Protection	961	Services
264	Guards, Watchmen, Marshals, Constables	962, 963	Services
265	Policemen, Detectives	964	Services
266	Sheriffs and Bailiffs	965	Services
267	Private Household Workers	980-984	Services

Chapter 3

Paying Information Workers

Lars Osberg

This chapter discusses the distribution and determination of earnings within the information sector and compares it with that within the goods and service sectors of the economy. Section 3.1 lays out the theoretical perspective while Section 3.2 discusses the determination of individual earnings. Section 3.3 considers the sample selection bias problem while section 3.4 examines whether the findings of Section 3.2 are robust with respect to an alternative reasonable specification of occupational categories. Section 3.5 focuses on the distribution of earnings.

Underlying this chapter is the viewpoint that the demand for labour is a derived demand and, as a result, the characteristics of particular labour markets will be greatly influenced by the characteristics of the production processes which that labour is engaged in. If the market for information is fundamentally different from the markets for goods and personal services, then the labour market for information workers will differ in important ways from the labour markets for goods and personal service workers. This chapter argues that the process of earnings determination differs substantially between the information and non-information producing sectors. However, this chapter also argues that the distribution of income in Canada would not be drastically different even if there were substantial shifts in the occupational composition of the labour force.

Since we rely on Canadian data throughout this chapter, we conclude this introduction by presenting Table 3.0, which is drawn from the work of Picot and Lavallee (1986). Using an input/output methodology which is rather similar to that of Chapter 2, these authors have examined the shift in the occupational composition of the Canadian labour force over the period 1971-1980. Here again we find evidence consistent with the "asymptotic stagnancy" argument developed in Chapter 1, that knowledge workers and service occupations grow in relative importance over time.

Indeed, in Canada over the 1970's, the information sector expanded in aggregate – but knowledge based occupations increased by 129.5% while the data sector increased by only 41.4%. Once one adjusts occupational trends for changes in the composition of aggregate output, knowledge occupations grew by 62% while the data sector shrank by 3.1%. As Table 3.0 indicates, this change was due primarily to changes in the skill mix within industries required to produce goods, *not* to changes in the industrial composition of demand (See also Chapter 2). The point of this chapter is to outline the implications of these trends for the determination and distribution of earnings.

3.1 Overview

In essence, in the market for information the buyer of information asks the seller of information a question (or questions), and pays the seller for the answer. The answer, however, may not be a "true" answer. Only if the buyer already knows the answer can the buyer know for certain whether he/she is being supplied with a true answer. In that case, however, the buyer would not have needed to purchase information. Hence there is an unavoidable problem of asymmetry in the market for information – a problem which is not inherently present in markets for goods and personal services.[1]

In some cases, of course, it is not possible for the seller of information to provide an answer which he/she can 'know' to be true; rather the seller of information provides an 'expert opinion' – e.g., in assessing the demand for coal in the U.S. in 1995 or in calculating the minimum steel required to support a particular bridge. In this instance the commodity being sold is an answer with a particular *probability* of being true. If the buyer of information could assess accurately the probability of particular answers being true, the buyer would be able to supply such answers and would not need to buy.

This distinction between answers which can be known to be true[2] and "expert opinions" is very close to our distinction between "data" and "knowledge". To fix ideas, let us examine the paradigm cases of travel agent and economic consultant. A travel agent who makes a reservation for a customer is selling the information that a seat will be

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[1] In principle, the characteristics of a physical object or a personal service can be objectively verified (although perhaps at some cost) by either the buyer or the seller at the time of the transaction and the transaction will still retain some utility value to the purchaser. Concealment of some characteristics (e.g., the "lemon car" example of Akerlof, 1970) may imply an asymmetry of information as to the *true* characteristics of a commodity, but even a "lemon car" has some market value. Symmetry of information as to the characteristics of the good or service being sold does not destroy the market, in distinct contrast to the market for information.

[2] By "known to be true", I mean that the seller of information assigns a prior to the probability of the answer being true which is an unbiased estimate of the actual probability and which is very close to one.

Table 3.0
Shifts in the Occupational Composition of the Labour Force Grouped into Knowledge, Data, Services and Goods Sectors

	(A) 1971 Employment (000's)	(B) Total % Change in Employment	(C) % Change due to Skill Mix
Knowledge			
Management/Admin.	101.7	260.5	158.6
Physical Sciences	21.4	12.2	-19.0
Life Sciences	5.4	88.5	49.2
Architect./Engin.	65.7	60.5	10.0
Other Arch./Eng.	53.7	64.2	12.6
Mathemat/Statistics	18.1	147.4	61.6
Social Sciences	4.9	156.6	41.3
Fine Arts	25.7	76.9	11.5
Performing Arts	11.8	116.3	29.6
Writing	12.7	91.8	26.6
Farm Management	20.7	80.8	81.2
	A* = 341.8	B* = 129.54	C* = 62.33
Data			
Management Support	144.4	21.2	-20.2
Social Work **	2.25	119.2	40.4
Law/Jurisprudence	15.5	96.7	-4.7
Library/Arch.	1.7	138.8	47.3
Health Diagnosing **	2.2	82.3	45.0
Nursing **	10.75	61.9	7.5
Other Health **	8.8	85.1	33.2
Steno Typing	204.4	31.5	-13.2
Bookkeeping	306.4	94.3	31.6
EDP Operator	38.3	72.9	17.8
Material Record	136.8	44.8	11.1
Library Clerk	13.1	27.2	-16.1
Reception	110.9	41.0	-5.1
Other Clerical	179.9	5.0	-27.0
Commodities Sales	682.0	30.4	-8.5
Service Sales	91.8	55.1	-4.8
Other Sales	34.2	-9.0	-33.3
	A* = 1983.4	B* = 41.44	C* = -3.112
Services			
Sports Recreation	6.9	119.9	20.5
Protection Services	33.8	39.8	-15.9
Personnel Services	115.5	67.7	-6.1
Apparel/Furnishing	28.4	55.9	-8.4
Other Services	130.8	41.1	-12.0
Social Work **	2.25	119.2	40.4
Health Diagnosing **	2.2	82.3	45.0
Nursing **	10.75	61.9	7.5
Other Health **	8.8	85.1	33.2
	A* = 339.4	B* = 55.45	C* = 6.912

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* $A^* = \Sigma A_i$; $B^* = \Sigma A_i B_i / A^*$; $C = \Sigma A_i C_i / A^*$

** The number of people employed in these occupations were divided between services and data (1/2 serv. & 1/2 data).

Table 3.0 (Cont'd)

	(A) 1971 Employment (000's)	(B) Total % Change in Employment	(C) % Change due to Skill Mix
Goods			
Food Preparation***	210.7	75.1	3.2
Lodging/Accommad.	49.5	28.7	-24.3
Farmers	250.2	-0.9	-0.7
Other Farming	246.0	-11.9	-16.1
Fishing/Trapping	21.9	67.7	4.7
Forest/Logging	49.0	-4.3	-8.9
Mining/Quarrying	52.4	9.1	-14.0
Mineral Ore	6.5	14.8	7.3
Metal Process	42.3	51.1	32.8
Clay/Stone Process	16.0	-5.7	-14.8
Chemical Process	30.2	26.9	3.2
Food Process	112.3	21.9	5.3
Wood Process	33.7	16.8	-3.8
Pulp/Paper	32.2	26.7	15.4
Textile Process	36.7	-5.9	-2.9
Other Processing	7.5	-16.5	-15.0
Metal Machining	84.0	-3.7	-20.8
Metal Shaping	112.1	27.1	1.7
Wood Machining	13.9	-17.9	-32.7
Clay/Stone Machin.	5.6	50.4	28.4
Other Machining	12.9	11.3	-8.7
Metal Fabricating	52.0	53.3	24.8
Electronic Fabricat.	79.0	38.5	14.2
Wood Fabricating	20.1	76.2	42.5
Textile Fabricating	143.3	10.5	3.0
Plastic Fabricating	21.6	49.0	12.3
Mechan./Repair	235.0	31.9	-0.8
Other Prod. Fabricat.	59.7	16.5	-4.7
Excavating/Paving	73.6	18.6	-4.4
Electrical Instal.	90.4	26.6	-3.7
Other Construction	364.1	18.0	-5.3
Air Transportation	7.0	98.1	58.2
Railway Transport.	27.8	0.6	-18.8
Water Transport.	13.8	-8.5	-27.6
Motor Transport.	235.0	27.9	-0.5
Other Transport.	4.6	-19.2	-33.0
Material Handling	183.1	4.8	-15.0
Printing	40.5	33.3	5.0
Stationary Engineer	30.9	9.1	-16.3
Electronic Equipment	5.6	29.0	-14.5
Other Crafts	4.0	72.3	-2.0
	A* = 3116.7	B* = 20.54	C* = -2.78

*** Conceptually we would like to distinguish the roles of cooks (goods workers) and waiter/ waitresses (whose delivery of meals contains a substantial personal service component) – but this is not possible with the Picot/Lavallée study.

available on a particular flight for that customer (and that a customer will be available for that seat), and to do so, the agent must send and receive messages within a clearly defined format. Both buyer and seller act on the premise that this data can be known to be true.[3] By contrast, an economic consultant who is called in to analyze a particular issue will deliver an assessment which is recognized by both client and consultant to be subject to error – but the client pays the consultant because he believes his own assessment would have had a *greater* probability of error.

Earlier, we defined the production of "knowledge" as "the generation or dissemination of new conceptual categories, relationships or hypotheses" i.e., the solution of a new problem or a new solution to an old problem. We argued that labour productivity in knowledge production is relatively technologically stagnant since it depends on human capability for creativity and problem solving. Our contrast of "knowledge" with "data" production (i.e., the manipulation of symbolic information within existing categories) was, however, an example of how one must sometimes impose a dichotomous categorization upon a continuous reality in order to achieve analytic simplicity.

In practice, there is a range of creativity, novelty and problem-solving in information production. Some information is almost entirely new and some is largely, if not entirely, routine.[4] Similarly there is a range of prior probabilities of the truth of a particular piece of information. The more original an idea, the more uncertainty is usually attached to estimating its truth. When we say, therefore, that some people produce "data" and some produce "knowledge" we are saying that some people produce information of a type which can have a probability of "almost one" of being true while others produce information which necessarily has an "appreciable probability" of falsehood.[5]

3.1.1 A More Formal Discussion

One can formalize the discussion somewhat by saying that for a *given* question by a "client" to a "consultant" there is some set of possible answers $A_i = [a_1 \ldots . a_n]$ by the consultant. Based on those answers the client will select from a set [D] of possible actions a particular response, presumably that response which maximizes expected utility – i.e., such that $D_i = \text{Max } E\,(u|A_i)$. Each response ($D_i$) will, *in fact*, generate an outcome (B_i)

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[3] Both parties typically recognize that certainty cannot be achieved in human life and there is some probability of computer glitches or other errors which might imply, for example, that the flight in question does not exist. Nevertheless, whether the flight exists is a routine piece of information, and the probability of its truth is nearly one.

[4] One can, for example, contrast the calculation of girder size for a bridge, a diagnosis of cancer or the writing of this book.

[5] However, we do not try to specify an exact numerical value for the probability of error which would distinguish between "data" and "knowledge". For a taxonomy of the degrees of creativity involved in information production see Machlup (1980:188/89).

for the client i.e., corresponding to each answer of the consultant, there is an *actual* payoff to the client which has some net utility value. Let us call the vector of payoffs B_i = [B_1 .... B_n] and let us order the vectors B_i and A_i in diminishing order of the net utility value to the client of the *objective* consequences of the action associated with that answer. By definition then, B_1 is the maximum possible net utility which the client can receive from an answer to his query and we can call the answer, A_1, which produces the response which generates this payoff the "true" or "best" answer, from the point of view of the client.[6]

The problem of the client is to select from a field of m potential consultants the one[7] who will maximize the expected value of payoffs, net of consultancy costs. We can use the subscript j to denote a particular consultant (reserving the value $j = 0$ for the case where the client "consults himself") and call the cost of using a particular consultant C_j. Any particular consultant will have a certain probability of giving specific answers to a defined question (i.e. a certain probability of giving the objectively "best" answer, the second "best" answer, etc. subject to $\sum_i P_{ij} = 1$). The problem of the buyer of information can then be put fairly simply as choosing the supplier of information who gives the greatest net benefit – *but* the buyer has to buy "ex ante". A maximizer of expected utility must therefore try to choose j so as to maximize V_j in equation (1).

$$(1) \quad V_j = \sum_i P_{ij} B_i - C_j$$

$$\text{subject to} \quad \sum_i P_{ij} = 1$$

$$j = 0, 1 \ldots . m.$$

The distinction between "data" production and the more general case can then be formalized as the assertion that there is some set of questions [I] and some subset [J] of all possible consultants for whom $P_{ij} = P_{ik}$ for all j, $k \in J$ and for all $i \in I$. In words, all consultants who 'qualify' as members of the groups J give the same value of answers to questions of type I. Buyers of information will then choose among members of this subset on the basis purely of relative cost (C_j). Given this buyer behaviour, sellers of information need only establish membership in the set J and maintain a competitive[8] pricing policy – i.e., this is a classic price-sensitive market place for those who are considered to be members of the set J.

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[6] Since, in general, $B_i \geq B_{i+1}$, there is the likelihood that some subset of answers all generate the same payoff. Without loss of generality we can call these "payoff-equivalent answers" and restrict our attention to the more interesting case where $B_i > B_{i+1}$. i.e. some answers are 'better' than others.

[7] At this stage we are neglecting the issues raised by Nitzan and Paroush (1985) in their discussion of multiple opinions and the "stopping rule" for obtaining advice. The discussion to follow would apply also to the case of multiple opinions.

[8] If any members of the qualified set J are to be hired as suppliers of information it must be the case that the differential in benefits between a correct answer by a "qualified" consultant and an occasionally incorrect answer is no greater than the difference in consultancy fees, i.e., $B_1 - C_{jI} < \sum_i (P_{ik} B_i - C_k)$ for all $k \notin J$.

In the case of 'knowledge' production, on the other hand, consultants may give *different* answers. It is recognized that for all potential consultants $\sum_i P_{ij}B_i < B_1$. We know, for example, that even the best chief executive officers occasionally make mistakes when asked the question "should we open a new factory?" The problem of the buyer of information remains that of maximizing net expected benefits as per equation (1). Sellers of information can, however, charge more for their services to the extent that they can influence the *perception* of the probability of giving "correct" or "nearly correct" answers. As a recent book advises aspiring consultants, "To a great degree the quality of the services you provide depends on the client's perception of how well you have performed. In fact, in a great many consulting situations, the quality of the services you provide is entirely a factor of the client's perception of that quality." (Holtz, 1983:3).[9]

Explicit consultancy contracts are, of course, a small part of the general market for knowledge – we have used the term 'consultant' above only as a shorthand for 'information provider'. We have argued that information is "data" when it is routine – (i.e. when any qualified provider would give the same answer) but that information is "knowledge" when there is a variation in the answers one can expect. Routinized provision of information is, of course, amenable to automation by computer – e.g., in the form of "expert systems". Personalized information provision is not, as yet at least, amenable to automation and is characteristic of much of business management, interpersonal interaction in education, artistic and scientific creation, etc.

In general, the buyer of information would like to ensure that he/she is not paying too much, based on a misperception of the true ability to provide correct answers of the "consultant". Formally, the "client" would like to minimize any excess in "perceived value" of each consultant – i.e., minimize $\sum_i P_{ij} B_i - \sum_i \hat{P}_{ij}B_i$, where $\hat{P}_{ij}$ is the actual probability that consultant j gives answer i. But for any given question at a given time, the client only observes the response given (A_i) and not the probability with which that response was selected. Observation over a number of "similar" trials offers clients a way to revise their prior estimates of the probability of a consultant giving 'good' or 'bad' answers and, over a large enough number of trials we would expect P_{ij} to converge to $\hat{P}_{ij}$ – which may be an explanation of why long term relationships between buyer and seller are so characteristic of the knowledge sector.[10] At any point in time, however, the market value of a knowledge provider is, set by $\sum_i P_{ij}B_i$ i.e., the *perceived* quality of answers. Hence credentials which are correlated with better answers will have market value, regardless of whether they are a *cause* of better answers being provided.

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[9] Indeed, as an occasional real world consultant I cannot resist the observation that credibility assigned often seems to vary directly with the fee one charges – for a discussion of markets where "quality" is thought to vary with price see Stiglitz (1987).

[10] An employer/employee relationship of the 'internal labour market' type is one form of long-term relationship, but another form is the 'family doctor' or the 'company law firm', whose services, on each of a number of successive occasions, are bought on the spot market. Where there is cost to "doing good work" (i.e., to maximizing $\Sigma\ \hat{P}_{ij}B_i$) the possibility of a long term relationship establishes incentives to the consultant not to shirk.

In the market for information workers, "screening equilibria" are particularly likely, since the employer inherently cannot know at the same time as labour is employed the value of the output of that labour and must, necessarily, judge the value of information labour as the *expected value* of answers provided. (In distinct contrast to producers of goods and personal service labour, the market value of whose output can be contemporaneously observed). However, the discussion here diverges from the traditional discussion of screening equilibria (see Stiglitz, 1984) in that it argues that screening can have a social return, not because better information is produced, but because information is *believed*.

Up to this point, we have argued the case for choice of an information provider *given* the question that the client asks. But this focus conceals part of the story since the type of "question" which is posed, i.e., its vagueness, level of abstraction or subject matter, can have a major impact on the cost of answering it. (C_j in our decision above). Indeed, since Fuchs (1968) many have argued that the output of the information sector is a joint product of both the producer and the consumer of information services. The communication of information requires, after all, a receiver as well as a sender, and the skills of the receiver will determine the acceptable format of message.[11]

To summarize, however, in the market for information the market value of the services of an information provider depend upon the *perceived* probability that they will provide "true" information, hence a variable (such as educational credentials) which is believed to predict the accuracy of advice will be associated with higher earnings.

One can contrast the production process for information with the production process for goods. A production function in goods, production can be used to describe the physical relationship between inputs into the production process (hours of labour time, energy and capital equipment used) and output. The marginal productivity of each factor input is therefore a definable magnitude[12] at a specific point in time, i.e. when production occurs. As well, in the case of goods, the output of the production process exists independently of the identity of the final consumer, hence production and consumption can be separately analyzed. In contrast, the value of information only becomes clear *after* it is produced and separation of production and consumption cannot be characteristic of the market for information.

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[11] The current discussion is, for example, phrased in English, with an appendage of minor mathematics, since it is hoped that this information will be received by a fairly wide audience. Drafting the chapter in this fashion takes more time (i.e., the author has lower labour productivity) than simply using jargon throughout, but takes less time than would be required if comprehensible english were to be substituted for all mathematical symbols. However, in a few pages some regression results will be presented, and no effort is made to explain the meaning of the term "linear regression" or "statistical significance", etc. Were such explanations to be attempted, the labour productivity of the author would drop even further, since explanation, even of such basic terms, requires time. Not providing such explanation presumes that the reader already possesses some information – an example of how the labour productivity of information suppliers depends on the skills of information purchasers.

[12] Usually, quality of output is implicitly held constant, or, equivalently output of different quality is labeled as different commodities.

The production of both goods and personal services creates an output with a definable value in a particular time period. The value of labour services can then be defined as the increment to total product within the current period of production – there is no need to *predict* its value. Payments to labour *can* be based on the contemporaneously measured value of such increments to output.[13] As a result, trades training for specific work roles may be rewarded, but *general* educational credentials will not,in general, be rewarded in goods and personal service occupations.

3.2 The Determination of Individual Earnings

Many studies (e.g., Dooley, 1986) have found that increased years of formal education are, for the labour force as a whole, strongly associated with higher individual earnings. For the labour force as a whole, this study is no exception. As column 6 of tables 3.1 to 3.3 indicate, when one examines all workers in Canada in 1980, one finds a clear and statistically significant relationship between years of formal education and annual income.[14] As table 3.1 indicates, those with post-graduate training obtain, on average, 49.8% higher income than high school graduates while those with less than 9 years of education receive approximately 11.9% less than high school graduates. Moreover, column 6 is entirely comparable with similar estimates from the recent literature both in magnitude of estimates obtained and in the methodology by which they were obtained (i.e. workers of *all* occupations were pooled for analysis). However, relatively few studies have examined how the economic returns to years of formal education might vary across occupational groups.

Columns 3, 4 and 5 reveal that if we compare workers in information sector occupations to workers in goods and personal services, there is a striking contrast in the role of post-secondary education in earnings determination. Among male workers in goods and personal services, there is no statistically significant difference between the earnings of high school graduates and those who have attended college, graduated from college or gone on to post-graduate training. Among information sector workers, individuals who have post-graduate training earn more than those who have only a bachelors degree, who earn more than those who attended, but did not graduate, from college, who in turn earn more, on average, than high school graduates. Among information sector workers, these relationships are strongly statistically significant and of significant magnitude.

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[13] Wage payments may, of course, vary over a working life to maintain incentives, as per Lazear (1979) or due to the working of internal labour markets – but the point is that one does not *need* to use credentials to predict the value of output.

[14] In public use versions of Canadian Census data, occupational designations are collapsed into 17 broad categories. The category "knowledge workers" is composed of occupational groups 02, 03, and 06. The category "data workers" is composed of 01, 04, 07 and 08. As noted in the introduction, the medical sector can be viewed as providing both diagnosis and personal assistance. As an approximation to this, workers in the "medicine and health" occupational group 09 (who are, in the majority, support staff, *not* physicians) were assigned, on a random 50:50 basis, to personal service and data sectors. As a result, however, some male physicians were randomly assigned to an improbable categorization – the personal service sector. This is the cause of the statistically significant coefficient on GUNV in table 33, column 5. When the personal service sector does not include any 'medicine or health' workers (see column 5, Table 3.3A) the effect of post-graduate training is statistically insignificant. Personal service is largely group 09 while groups 10, 11, 12, 13, 14, 15 are goods workers. Note that those with "other occupations" or "not specified" have not been assigned to any of the above categories. For some purposes, the breadth of these classifications is useful since it implies that entry to these occupational groups is not formally restricted (e.g., by licensing requirements) to individuals who have particular educational qualifications (see Table 2).

However, among male workers in all sectors (Table 3.3), those who did not graduate from high school received significantly lower annual incomes than those who did – suggesting that in all sectors a minimum norm of formal education may exist. Furthermore, among male goods workers (although for no other category of worker) the possession of trades or technical training is associated with a higher level of annual income.

Within the information sector, Table 3.1 to 3.3 all indicate, as one would expect, that years of formal education affect annual income in both knowledge based occupations and in those based on data generation. Post-graduate education is strongly associated with higher incomes within the knowledge sector, and the statistical relationship is significant at the 1% level of confidence. Indeed, for females (and when males and females are pooled in one sample) *only* post-graduate education matters. Given the "roughness" of the occupational categories in this data set, we are encouraged by the support it shows for our basic perspective – that formal education is rewarded within the information sector, with a significantly greater role played by advanced degrees within knowledge based occupations.

The benefit of separating female and male workers in regressions[15] such as those reported in Table 3.2 and 3.3 is that one does not confound issues of gender discrimination in labour markets with differential rewards to education, province of residence or experience. However, the cost of such a methodology is that differentiation of occupational role along gender lines may be absolutely crucial to understanding some labour markets. Many writers have argued that it is no accident that most jobs in data generation (e.g., secretary, clerk) are filled by women whereas the majority of workers in the knowledge sector (e.g., engineers, business executives) are male. In this context Table 3.1, which reports the results of regressions run on male *and* female workers may be of some interest. One can note that the differential in income ascribable purely to gender (under the maintained hypothesis that other characteristics are similarly rewarded for males and females) is significantly less in the information sector, (.526) than in goods (.760) or in personal services (.657).

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[15] The major emphasis in this discussion is on the role which education plays in the determination of individual earnings within occupational categories. However, we should note that the coefficients on the control variables includes Tables 1 and 3 above have reasonable magnitude and appropriate signs. The proxy for work experience, (t = age - years of schooling - 5) is entered as a quadratic, and both the linear and quadratic term are highly significant statistically. Jointly, these coefficients imply that the turning point in the cross sectional age/earnings lifetime profile occurs after approximately 28 to 30 years. The ln of weeks worked per year is strongly significant, with a coefficient not significantly different from one (as one would expect). The dummy variables for regional effects show, as expected, lower wages for workers in the province of Quebec and Atlantic Canada. However, it is noteworthy that regional affects are most marked among workers in goods-based occupations, while there appears to be no very strong impact of province of residence on the annual earnings of personal service workers.

Table 3.1
Earnings Determination Among all Canadian Workers - 1980

Independent Variable	Knowledge	Data	Information	Goods	Personal	All
Education						
<9 years	-.506	-.096	-.121	-.033	-.191	-.119*
	(-1.5)	(-1.3)	(-1.7)	(-.5)	(-1.6)	(-2.9)
9-11 years	-.138	-.094	-.106'	-.0042	-.031	-.102*
	(-.5)	(-1.9)	(-2.2)	(-.1)	(-.3)	(-2.9)
Trades	.044	.082'	.083'	.190*	.197'	.117*
	(.3)	(2.0)	(2.1)	(3.5)	(2.1)	(3.8)
Non-grad	.029	.250*	.235*	-.057	.449*	.220*
	(.18)	(5.3)	(5.1)	(-.6)	(3.5)	(5.6)
BA GRAD	.220	.411*	.376*	.128	.214	.364*
	(1.7)	(8.2)	(8.3)	(.7)	(1.2)	(8.7)
GUNV	.482*	.473*	.506	-.791'	.472	.498*
	(3.3)	(7.6)	(9.1)	(2.5)	(1.7)	(9.5)
Experience*						
T	.050*	.029*	.032*	.0422*	.026*	.0339*
	(3.7)	(6.8)	(8.0)	(8.1)	(3.4)	(11.7)
T^2	-.0008*	-.0006*	-.0006*	-.00078*	-.0005*	-.00065*
	(-2.9)	(-6.8)	(-7.6)	(-8.8)	(-3.7)	(-11.7)
Males	.297*	.554*	.526*	.760*	.657*	.593*
	(3.1)	(18.5)	(18.6)	(13.9)	(9.6)	(27.2)
Region						
B.C.	.303'	.123*	.147*	.195*	.233'	-.164*
	(2.2)	(2.6)	(3.2)	(3.1)	(2.3)	(4.7)
Prairie	.189	-.021	.002	.054	-.053	-.016
	(1.6)	(-.5)	(.04)	(1.0)	(-.6)	(.5)
Quebec	.069	.059	.064	.031	.030	.05
	(.6)	(1.6)	(1.8)	(.6)	(.4)	(1.8)
Atlantic	-.084	-.123'	-.116'	-.0756	-.111	-.0809
	(-.4)	(-2.0)	(-1.97)	(-1.0)	(-.9)	(-1.9)
Ln (Weeks)	1.17*	1.03*	1.05*	.827*	1.06*	.973*
	(8.5)	(30.1)	(31.4)	(19.8)	(17.0)	(40.8)
Constant	4.33*	4.92*	4.82*		4.53*	4.99
$\bar{R}^2$	.41	.49	.48	.44	.50	.46
N	286	1907	2185	1122	540	4011
F	15.0	130.3	143.5	64.2	39.3	246.4

Occupational Classification - 1981 Census:

Knowledge	= 02 + 03 + 06
Data	= 01 + 04 + 1/2 (05) + 07 + 08
Personal Service	= 1/2 (05) + 09
Goods	= 10 + 11 + 12 + 13 + 14 + 15

00 and 16 excluded

* T = Age − Schooling − 5

Dependent variable in all tables is ln (1980 annual earnings)

However, with respect to education, all three tables carry the same conclusion. In the information sector education pays, especially university and post-graduate education. Elsewhere in the economy, only trades training really matters.[16]

3.3 Correction for Sample Selection Bias

The use of census data as a basis for regression analyses such as those of Tables 3.1 to 3.3 allows a researcher the luxury of a very large sample size. This implies that even if a group of interest (such as college graduates in goods occupations) is a small *proportion* of the population, the absolute number of cases is still sufficiently great that one can place some reliance on regression results using dummy variables such as those reported in Tables 3.1 to 3.3. Furthermore, these results have the very considerable advantage that they are compatible with "common sense". Even though the economics literature has been dominated, for some years, by a "human capital" perspective, (which argues that education is, *in general*, rewarded in the labour market) few people would find it surprising that higher education does not increase one's income as a truck driver or as a waitress, *or* that more highly educated consulting engineers are likely to do better, on average.

However, Census data, although offering very large sample sizes, has only a limited array of variables available on the characteristics of each individual respondent. As well, individuals *choose* their occupations, and exercise substantial choice over their education. Hence, it *may* be the case that regression results such as those reported in Tables 3.1 to 3.3 are susceptible to problems of sample selection bias – i.e., individuals may have "self-selected" into particular occupational categories in the labour market, implying that ordinary least squares regression results may be biased.

But in assessing the probability that individuals will belong to particular occupational categories, one can think of potential self-selection in two rather different ways. If there is a dispersion in the rate of return to education, then only some of the individuals who have higher education will, in fact, receive higher wages. If at any point in time those individuals who receive an above average return in the labour market on their past investments in education select a particular group of occupations because they prefer the working conditions, job status or other non-monetary advantages of that category of occupations[17] then Tables 3.1 to 3.3 reveal simply a preference for a particular

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[16] With the twin qualifications that functional illiteracy (less than 9 years schooling) is a handicap for male workers and some female service workers may get some return to post-secondary education.

[17] If individuals with higher education choose a particular category of occupations in order to get a monetary return to their higher education, then that is exactly the point we wish to make – that education is rewarded financially in some occupational categories but not in others.

Table 3.2
Earnings Determination Among Canadian Female Workers - 1980

Variable	Knowledge	Data	Information	Goods	Personal	All
Education						
<9 years	-.174	-.219*	-.223*	-.028	-.019	-.186*
	(.5)	(-3.7)	(-3.8)	(-.3)	(-.2)	(-5.4)
9-11 years	-.155	-.159*	-.159*	-.039	-.024	-.1696*
	(-.6)	(-4.8)	(-4.8)	(-.5)	(-.4)	(-6.2)
Trades	.048	.083*	.082*	-.099	.377*	.101*
	(.3)	(3.0)	(3.0)	(-.9)	(5.8)	(4.0)
Non-grad	.073	.223*	.216*	.3296	.459*	.256*
	(.4)	(6.5)	(6.3)	(1.8)	(5.0)	(8.0)
BA GRAD	.302	.456*	.435*	.284	.704*	.478*
	(1.9)	(11.8)	(11.9)	(1.0)	(5.7)	(13.4)
GUNV	.477*	.631*	.612*	-.990*	.036	.602*
	(2.8)	(10.9)	(12.0)	(-2.7)	(.1)	(11.7)
Experience						
T	.026	.019*	.0196*	.111	.017*	.017*
	(1.8)	(6.4)	(6.8)	(.9)	(2.9)	(6.9)
T^2	-.00066'	-.00040*	-.00041*	-.00006	-.00031*	-.00035*
	(-2.1)	(-6.4)	(-6.8)	(-.4)	(-.28)	(-6.8)
Region						
B.C.	.011	.088*	.084*	.2795'	.207*	.112*
	(.1)	(2.7)	(2.6)	(2.4)	(3.0)	(3.9)
Prairie	.063	.011	.017	-.127	.033	-.0099
	(.4)	(.4)	(.6)	(-1.4)	(.6)	(-.4)
Quebec	.213	.131*	.138*	-.019	.175*	.126*
	(1.7)	(4.8)	(5.1)	(-.3)	(3.0)	(5.4)
Atlantic	-.377	-.106'	-.124*	-.069	.0008	-.091'
	(-1.8)	(-2.5)	(-2.9)	(.6)	(.01)	(-2.5)
Ln (Weeks)	1.21*	1.09*	1.096*	.962*	1.052*	1.07*
	(9.9)	(53.2)	(53.7)	(16.9)	(26.2)	(61.7)
Constant	4.39*	4.78	4.76*	5.199*	4.51*	4.80*
$\hat{R}^2$	.31	.44	.43	.35	.41	.42
N	299	4121	4420	633	1204	6407
F	11.5	252.5	261.0	27.59	65.9	358.1

(t statistic bracketed)
* significant at 1%
' significant at 5%

Table 3.3
Earnings Determination Among Canadian Male Workers - 1980

Variable	Knowledge	Data	Information	Goods	Personal	All
Education						
<9 years	-.318' (-2.0)	-.150* (-2.8)	-.166* (-3.3)	-.084* (-2.5)	-.292* (-3.9)	-.159* (-6.7)
9-11 years	-.355* (-2.6)	-.163* (-4.5)	-.172* (-4.9)	-.047 (-1.5)	-.187* (-2.8)	-.120* (5.8)
Trades	.065 (.9)	.039 (1.2)	.050 (1.7)	.110* (3.9)	.035 (.6)	.059* (3.1)
Non-grad	.151 (1.8)	.146* (4.2)	.150* (4.7)	-.013 (-.3)	.0597 (.7)	.113* (4.6)
BA GRAD	.269* (3.9)	.364* (10.3)	.341' (11.2)	.016 (.2)	.015 (.1)	.297' (11.6)
GUNV	.395* (5.0)	.436* (11.0)	.431* (12.4)	-.145 (.7)	.512* (3.8)	.402' (13.2)
Experience						
T	.059* (8.3)	.057* (17.7)	.057* (19.6)	.042 (14.3)	.046* (8.6)	.049* (27.1)
T^2	-.00095* (-6.5)	-.00095* (-15.6)	-.00095* (-17.0)	-.00075* (-14.1)	-.00079* (-8.5)	-.00087* (-25.3)
Region						
B.C.	.089 (1.2)	.049 (1.4)	.055 (1.7)	.094* (2.9)	.009 (.1)	.065* (3.1)
Prairie	.027 (.4)	-.007 (-.2)	-.003 (-.1)	.011 (.4)	.023 (.4)	.010 (.5)
Quebec	-.006 (-.1)	-.027 (-1.0)	-.025 (-1.1)	-.037 (-1.4)	-.052 (-.9)	-.02 (-1.4)
Atlantic	-.219' (-2.2)	-.119* (-2.7)	-.139* (-3.4)	-.203 (-5.1)	-.073 (.9)	-.156* (-5.9)
Ln (Weeks)	.746* (10.9)	1.01* (25.9)	.945* (28.1)	.856* (34.7)	1.03* (19.5)	.921* (51.3)
Constant	6.26*	5.25*	5.51*	5.98*	5.198*	5.66*
$\bar{R}^2$	.31	.30	.30	.31	.40	.33
N	811	3363	4174	3865	875	9501
F	29.5	112.8	140.7	134.7	45.7	360.7

occupation by those for whom education would, in any event, pay. Following this line of reasoning, one would correct for potential sample selection bias by attempting to predict the probability of entry into alternative occupational categories using variables which might indicate a *current* preference for non-monetary job attributes, such as current education and work experience, socio-economic origin, parental education, etc. This is the model labelled "PROBIT1" in table A1, columns 1 and 3. The sample selection bias correction term calculated on this basis is included as variable "Lambda" in Tables A2(a) and A3(b) under the columns headed SS1.

An alternative perspective would be that individuals make a joint choice of an occupational goal and an educational strategy, knowing that access to particular occupations is rationed by educational credentials. Models of rationing and educational credentialism, such as those of Arrow (1973), Stiglitz (1975, 1984), or Bowles and Gintis (1976) imply that the correlation between education and earnings that one observes in the labour market really represents a return to innate ability (Arrow, Stiglitz) or to socio-economic class advantage (Bowles and Gintis). Following this line of thought, one would only use, as predictors of occupational status, variables which are *prior* to educational attainment (e.g., father's education, socio-economic status) or are not the result of individual choice (e.g., ethnic origin, health status, etc.). In Table A1 we refer to this model as "PROBIT2". In Table A2 and A3, the sample selection bias correction term calculated on this basis and labelled "Lambda" is included in the columns headed SS2.

As the appendix to this chapter indicates, however, when we test the possible significance of sample selection bias, in either sense, the conclusion is that it is statistically insignificant. We therefore conclude that the differences between the information and goods and personal service sectors revealed in tables 3.1 to 3.5 are *not* the result of sample selection bias.

3.4 Alternative Occupational Classifications

The categorization of the labour force adopted in Table 3.1 to 3.3 is the closest match possible, given that publicly available microdata from the Canadian Census is only coded to the two-digit level of occupational classification, to the analysis of shifts in the occupational structure of the U.S. labour force earlier reported in chapter 2. Throughout this volume, we adopt a four-fold categorization of the labour force – knowledge, data, goods and service occupations – in the hope that this "broadbrush" categorization of the labour force may produce some insight into fundamental long-run trends in occupational composition of the labour force. However, it is clear that although the vast majority of detailed occupational titles fall easily into one or the other of these four categories, any categorization of the labour force that reduces the real world's diversity of occupations into only four groups will necessarily involve some problems of classification.

The largest single cluster of occupations which are difficult to classify are, as earlier noted, the "caring" professions, who combine in their work roles the diagnosis of individual ailments *and* personal attention to individual needs. One can, for example, see psychiatrists, social workers and some medical personnel as combining data generation and personal service functions. In Chapter 2, and in Section 3.3 of this chapter the records of individuals who are coded as belonging to the category "medicine and health occupations" have been randomly assigned, on a 50/50 basis, to "data" and to "personal service".[18]

In addition, within the category of "medicine and health occupations" there are a number of different occupational roles, of whom "physicians" are a minority. Another difficulty is that even within detailed four-digit occupational classifications there are often a range of work duties. Academics are familiar with the fact that the category "university professor" includes some who focus almost entirely on teaching, and some who emphasize almost entirely research. Although student questions are almost always slightly different and communicating in classroom interaction is never quite routine, still it cannot be denied that straight-forward lecturing (especially in introductory courses) is a fairly routine, data transmission, function. Similarly, some of those whose occupational title is "business manager" are involved primarily with the routine generation and manipulation of standardized information, while some are involved primarily with non-routine problem solving, and one suspects that there is a gradual transition in the relative importance of these functions as one moves up the hierarchy of business managers.

Of course, the logic of asymptotic stagnancy is of equal validity for an analysis of the transformation of work responsibilities *within* detailed occupational categories as for analysis of the relative weight of occupational roles in the labour force as a whole. If an occupation produces an output that is the result of two activities, one of which is "progressive", with increasing labour productivity over time, and one of which is "stagnant" with constant labour productivity, then the asymptotic stagnancy argument implies that the "stagnant" activity will increase in relative importance over time.[19]

However, although impressionistic discussions of the nature of work roles within occupational titles is easily come by, reliable quantitative data is not. The implication is that we must work with data on the occupational composition of the labour force in order to assess the model of information production presented in chapter one – *and* that there might be reasonable alternative operationalizations of the knowledge/data/service/goods categorization of the labour force.

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[18] Of course, to the extent that diagnoses of ailments will differ among practitioners, health professionals will be generating "knowledge" in the sense of non-routine information, as defined above in section 3.1. Clearly, in some cases this is what health professionals do. However, we have adopted the view that such cases represent a relatively small minority of the ailments encountered by medical practitioners, and that in the vast majority of ailments, medical practitioners would agree in their diagnosis – i.e. they are generating "data" in the sense defined in section 3.1 above. In this sense, we agree with the perspective that much of the diagnostic function of medical professionals could, potentially, be replaced by "expert systems". However, our view is that the personal attention paid to patients *cannot* be similarly automated, and that such personal attention is very often an important part of the healing process.

[19] Authors, for example, must not only conceive the content of their work, but also produce a record of it. Since the development of word processing technology, the amount of time one must spend in physically producing a manuscript, and in proof-reading or revisions, has diminished substantially.

In this section we present the results of an analysis of earnings determination similar to that conducted in section 3.3, within an alternative specification of occupational categories. The point of the exercise is to assess whether the results presented in section 3.2 are "robust" with respect to plausible alternative specifications – as we shall note, the results are, if anything, even more supportive than those discussed earlier.

Tables 3.1A to 3.3A are similar to Tables 3.1 to 3.3 presented earlier, but utilize a somewhat different definition of occupational sectors. The alternative classification is substantially more liberal in its classification of information based occupations as "knowledge" rather than "data" producers.[20] In addition, in Tables 3.1A to 3.3A individuals in the classification "medicine and health occupations" have *not* been split between data and personal service as in Tables 3.1 to 3.3, rather they have all been assigned to the "data" category.

In all these tables, both the variable T (years of potential work experience = age - years of schooling - 5) and the variable T^2 are entered with the expectation that a negative coefficient on T^2 (the square of potential experience) will indicate a diminishing rate of increase of income as individuals age. These expectations are confirmed for male workers and for male and female workers considered together. However, there is some expectation in the literature that this variable will be a poor proxy for potential work experience for female workers, since women have, in the past, been more apt to leave the paid labour force to undertake, temporarily, child care responsibilities. It is notable that in both Table 3.2A and Table 3.2 the "potential work experience" variable is statistically significant, with expected sign and reasonable magnitude, for both types of information workers and for personal service workers. It is only female workers in goods based occupations for whom there is no statistically significant payoff to potential experience. (A finding that is consistent with the view that female employment in manufacturing, etc., is often employment in "marginal" establishments – see Osberg, 1986.)

Using either categorization of occupational titles, the regressions reveal regional differences in earnings which are reasonable, in both size and magnitude. However, it is notable that the most clearly established differential is that between British Columbia and the rest of Canada. The negative regional differential for Atlantic workers is relatively small (-8%) and at the margin of statistical significance.

As well, the alternative specification agrees with that of Tables 3.1 to 3.3 in assigning virtually no role to education in income determination in non-information based occupations. Education, and in particular post-secondary education, is, however, highly significant in determining individual earnings in the information sector.[21]

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[20] In Tables 3.1A to 3.3A the "knowledge" based occupations are defined as those in occupational group 01, 02, 03, 04 and 06, as defined in the 1981 Canadian Census while individuals in occupation groups 05, 06 and 08 are classified as "data" workers.

[21] One must qualify the above to the extent that Table 3.2A indicates that female workers in personal service occupations may receive some benefit from post-secondary education.

Table 3.1A
Earnings Determination Among Canadian Workers - 1980

(1) Variable	(2) Knowledge	(3) Data	(4) Information	(5) Goods	(6) Personal	(7) All
Education						
<9 years	-.067	-.054	-.106	-.033	-.163	-.119*
	(-.5)	(-.6)	(-1.5)	(-.5)	(-1.3)	(-2.9)
9-11 years	-.254*	-.0326	-.1081	-.0042	-.0082	-.102*
	(-2.3)	(-.6)	(-2.2)	(-.1)	(-.1)	(-2.9)
Trades	-.007	.1191	.0991	.190*	.0228	.117*
	(-.1)	(2.5)	(2.5)	(3.5)	(.2)	(3.8)
Non-grad	.157*	.180*	.242	-.057	.3331	.220*
	(2.3)	(2.9)	(5.3)*	(-.6)	(2.2)	(5.6)
BA GRAD	.245*	.294*	.375*	.128	.164	.364*
	(3.9)	(3.4)	(8.3)	(.7)	(-.6)	(8.7)
GUNV	.425*	.223*	.515*	-.7911	-1.95*	.498*
	(6.1)	(1.8)	(9.4)	(2.5)	(-2.6)	(9.5)
T	.0426*	.019*	.0311*	.0422*	.0283*	.0339*
	(6.8)	(3.8)	(7.9)	(8.1)	(3.3)	(11.7)
T2	-.00068*	.00046*	-.00066*	.00078*	-.00056*	-.00065*
	(-5.4)	(-4.5)	(-7.5)	(-8.8)	(-3.8)	(-11.7)
Male	.412*	.484*	.513*	.760*	.822*	.593*
	(9.8)	(12.0)	(18.3)	(13.9)	(10.9)	(27.2)
B.C.	.0658	.234*	.162*	.195*	.171	.164*
	(1.0)	(3.9)	(3.6)	(3.1)	(1.5)	(4.7)
Prairie	-.004	.0079	.0091	.054	-.0757	.016
	(-.07)	(.15)	(.2)	(1.0)	(-.8)	(.5)
Quebec	.074	.039	.0621	.031	.014	.05
	(1.5)	(.8)	(1.8)	(.6)	(.2)	(1.8)
Atlantic	-.062	-.127	-.097	-.0756	-.179	-.0809
	(-.7)	(-1.7)	(-1.7)	(-1.0)	(-1.3)	(-1.9)
Ln (Weeks)	.961*	1.077*	1.046*	.827*	1.026*	.973*
	(17.7)	(26.9)	(32.1)	(19.8)	(15.1)	(40.8)
Constant	5.24*	4.81*	4.84*		4.54*	4.99
$\bar{R}^2$	.41	.44	.47	.44	.54	.46
N	985	1281	2266	1122	435	1011
F	50.4	73.96	146.9	64.2	37.8	246.4

dependent variable is ln (1980 earnings)

Source: micro-data from 1981 Census of Canada Public Use Sample

* significant at 1%

1 significant at 5%

(t ratio in brackets)

Table 3.2A
Earnings Determination Among Canadian Female Workers - 1980

(1) Variable	(2) Knowledge	(3) Data	(4) Information	(5) Goods	(6) Personal	(7) All
Education						
<9 years	-.363* (-2.36)	-.162* (-2.79)	-.21* (-3.79)	-.028 (-.325)	-.065 (.784)	-.186* (-5.35)
9-11 years	-.096 (-1.02)	-.158* (-4.68)	-.153* (-.4.71)	-.039 (0.489)	.0096 (.132)	-.170* (-6.23)
Trades	.072 (1.02)	.099* (3.61)	.101* (3.85)	-.099 (-.943)	.161* (1.93)	.101* (4.04)
Non-grad	.284* (4.21)	.113* (2.91)	.215* (6.59)	.330[1] (1.81)	.288* (2.13)	.256* (7.97)
BA GRAD	.432* (6.87)	.281* (4.71)	.439* (12.34)	.284 (1.01)	.549* (3.23)	.478* (13.41)
GUNV	.551* (7.51)	.338* (2.88)	.593* (11.82)	-.99* (-2.73)	-1.88* (-2.49)	.602* (11.69)
T	.031* (4.71)	.013* (4.26)	.019* (6.87)	.0075 (.896)	.012[1] (1.81)	.017* (4.04)
T^2	-.00057 (-4.01)	-.0003* (4.74)	-.0004* (-6.82)	-.000063 (-.392)	-.00026* (-.208)	-.00035* (-6.84)
B.C.	-.062 (-.94)	.142* (4.07)	.082* (2.63)	.280* (2.41)	.241* (2.91)	.112* (3.85)
Prairie	-.057 (-1.01)	.047[1] (1.53)	.023 (.828)	-.127 (-1.422)	.028 (.412)	-.0099 (-.396)
Quebec	.225* (4.23)	.108* (3.71)	.148* (5.71)	-.019 (-.263)	.127[1] (1.82)	.126* (5.39)
Atlantic	-.132[1] (-1.61)	-.113* (-2.42)	-.115* (-2.79)	-.069 (-.586)	-.0075 (-.07)	-.091* (-2.45)
ln (Weeks)	1.152* (24.50)	1.066* (50.06)	1.09* (55.37)	.962* (16.92)	1.026* (22.56)	1.074* (61.65)
Constant	4.53[A]	4.92*	4.76*	5.20*	4.59*	4.80*
$\hat{R}^2$	.387	.43	.43	.35	.38	.42
N	1274	3471	4745	633	879	6047
F	62.8	203.6	275.4	27.59	42.6	358.1

Table 3.3A
Earnings Determination Among Canadian Male Workers - 1980

(1) Variable	(2) Knowledge	(3) Data	(4) Information	(5) Goods	(6) Personal	(7) All
Education						
<9 years	-.189* (-2.6)	-.083 (-1.2)	-.163* (-3.3)	-.084* (-2.5)	-.317* (-4.2)	-.159* (-6.7)
9-11 years	-.221* (-4.3)	-.071 (-1.4)	-.164 (-4.6)*	-.047 (-1.5)	-.220* (-3.3)	-.120* (-5.8)
Trades	-.023 (-.6)	.056 (1.2)	.046 (1.6)	.110* (3.9)	.035 (.6)	.059* (3.1)
Non-grad	.111* (2.8)	.094 (1.8)	.152* (4.8)	-.013 (-.3)	.0369 (.4)	.113* (4.6)
BA GRAD	.237* (6.5)	.291* (4.3)	.336* (11.1)	.016 (.2)	-.039 (-.3)	.297* (11.6)
GUNV	.346* (8.7)	.310* (3.7)	.431* (12.5)	-.145 (.7)	.465 (1.8)	.402* (13.2)
Experience						
T	.059* (15.6)	.045* (9.9)	.057* (19.8)	.042 (14.3)	.045* (8.3)	.049* (27.1)
T^2	-.00094* (-12.6)*	-.00081* (-9.6)	-.00096* (-17.2)	-.00075* (-14.1)	-.00078* (-8.1)	-.00087* (-25.3)
Region						
B.C.	-.019 (-.5)	.180* (3.2)*	.053 (1.6)	.094* (2.9)	-.006 (.1)	.065* (3.1)
Prairie	-.051 (-1.5)	.088 (1.9)	-.0004 (.02)	.011 (.4)	-.039 (-.6)	.010 (.5)
Quebec	-.009 (-.3)	-.021 (-.5)	-.027 (-1.1)	-.037 (-1.4)	-.051 (-.9)	-.02 (-1.4)
Atlantic	-.148* (-3.0)	-.105 (-1.6)	-.137* (-3.3)	-.203 (-5.1)	-.0785 (-.9)	-.156* (-5.9)
Ln (Weeks)	.914* (70.9)	.969* (19.2)	.951* (28.6)	.856* (34.7)	1.024* (19.0)	.921* (51.3)
Constant	5.71*	5.43*	5.48*	5.98*	5.21*	5.66*
$\bar{R}^2$	.30	.26	.31	.31	.40	.33
N	2603	1638	3865	3865	807	9501
F	87.2	45.2	134.7	134.7	41.9	360.7

dependent variable is ln (1980 earnings)

Source: micro-data from 1981 Census of Canada Public Use Sample

* significant at 1%

1 significant at 5%

(t ratio in brackets)

Furthermore, in each of Tables 3.1A, 3.2A, and 3.3A, the return to post-graduate education in the knowledge sector is significantly greater than in data production.

We therefore conclude that this alternative operationalization of the knowledge/data/goods/services categorization of occupations does not imply qualitatively different estimates of earnings equations, within occupational categories. Doubtless, other operationalizations could be attempted, but since we have tried two operationalizations which represent fairly extreme alternatives, one might expect other operationalizations to generate results intermediate between those reported here.

3.5 Distribution of Earnings

A great deal of the social concern surrounding a possible transition to a "post-industrial" economy revolves around the anticipated impact of such a transition on income distribution within advanced economies. The "pessimistic scenario" emphasizes the shift in employment from goods production to personal services, and argues that jobs in the personal service sector are typically lower paid, with less employment security and fewer possibilities for advancement. The decline in employment in steel production in OECD nations and the coincident increase in employment in the fast food sector is often cited, (e.g. Piore and Sabel, 1984) By this scenario, post-industrial society would be marked by increased inequality in income distribution and decreased social mobility. However, the "optimistic scenario" for the information economy emphasizes the increased skill level required in information sector jobs and in those jobs in goods production which will still remain.

A full theory of income distribution must predict the equilibrium number of individuals who will supply labour and whose labour is demanded by firms at each income level.[22] Such a theory does not now exist, since theories of human capital investment focus solely on the supply side of labour markets. In this chapter we do not rectify this lacuna in the literature, but we do present some information on intrasectoral and intersectoral inequality in earnings.

As Table 3.4 indicates, among male Canadian workers there is less inequality among goods workers and among knowledge sector workers than is typical for the labour market as a whole, or for other sectors of the labour market. (Tables 3.4 to 3.6 corresponds to the categories discussed in Sections 3.2 and 3.3. Tables 3.4A to 3.6A presents the alternative specification discussed in Section 3.4). Annual earnings are higher on average in goods production than in personal service, hence a shift of employment from goods to personal services represents a shift to an aggregate distribution of earnings which is increasingly dominated by occupations with lower average earnings and greater dispersion of earnings. In the standard "two sector" model of technological development (see Baumol, 1967) the goods and personal service sector are emphasized, and the prediction is that the personal service sector will expand continually in relative importance in the labour force. Clearly, there are some grounds for paying attention to the "pessimistic scenario" for the post-industrial society.

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[22] The argument that one must consider explicitly the demand side of labour markets in any full analysis of the income distribution is developed at more length in Osberg (1984, Chs.8-10).

However, in our three sector model of development, we emphasize the importance of the hybrid sector, information services, which can be disaggregated into the knowledge and data sectors. We argue that the relative weight of knowledge workers will increase, over time, within the information sector although we cannot as yet specify a model which indicates the relative importance of the information sector, as a whole, in the aggregate economy. We note, however, from Tables 3.4 to 3.6, that those employed in knowledge production have higher average annual earnings with less intrasectoral dispersion of earnings than those employed in data production. Shifts in employment within the information sector will therefore increase the relative weight of the more egalitarian, higher income component of the information sector.

However, one must hasten to caution that average incomes, by employment sector, are extremely unlikely to remain unchanged by any technologically induced shifts in the demand for labour by occupational type. Both average earnings within each sector and the inequality of earnings within sectors will change somewhat in future years. But, one still needs to keep the impact of any sectoral shifts in employment on aggregate economic inequality in context. As columns 1-5 of Tables 3.4 to 3.6 indicate, there is substantial inequality in annual earnings *within* occupational categories.

As several authors have noted (e.g. Cowell, 1980, Shorrocks 1980) the Theil index of inequality is the only index of income inequality which can be appropriately disaggregated into the within-sector and between-sector components of aggregate inequality. In aggregate most of the inequality in annual earnings revealed in line 6 of Table 3.6 is due to intra-sectoral inequality – i.e. intra-sectoral inequality in annual earnings accounts for some 80% of the aggregate inequality in annual earnings[23] (as measured by the Theil index).

In order to accurately estimate the impact on earnings inequality of shifts in labour force composition one needs to know the elasticities of demand and supply of labour, by sector, as well as the magnitude of labour force shifts. Such information is not available, but simple calculations can provide an upper bound to likely impacts on income inequality. Suppose, for example, that average earnings, and the intra-sectoral dispersion of earnings, are unaffected by shifts in labour force composition. Suppose further that goods employment is cut in half and that jobs in data production are similarly halved – with goods workers flowing into personal service and data workers switching to knowledge production (i.e. the "information sector", as a whole, remains an unchanged proposition of total employment).

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[23] The fact that intra occupational earnings in equality often approaches the degree of inequality found in the income distribution as a whole has long been noted see Lydall (1957). Using Table 3.6A intrasectoral inequality represents 81% of total earnings inequality.

Table 3.4
Distribution of Annual Income by Occupational Sector - male workers 1981

		Quintile Shares					Gini Ratio	Coefficient of variation	Theil index	Average income
		1	2	3	4	5				
a.	Goods	6.9	14.8	20.3	24.5	33.3	.27	.508	.13	17851
b.	Personal Service	5.3	13.7	19.4	25.3	36.4	.31	.604	.18	16120
c.	Knowledge	6.7	14.6	19.4	24.5	34.9	.28	.523	.14	23103
d.	Data	6.9	13.7	18.1	23.5	37.8	.31	.593	.16	23587
e.	Information (= c + d)	6.9	13.8	18.4	23.6	37.3	.30	.581	.16	23493
All	(a + b + e)	6.8	13.7	19.0	23.7	36.8	.31	.582	.16	20086

Table 3.5
Distribution of Annual Income by Occupational Sector - female workers 1981

		Quintile Shares					Gini Ratio	Coefficient of variation	Theil index	Average income
		1	2	3	4	5				
a.	Goods	4.5	12.0	18.5	25.3	39.7	.353	.641	.209	8309
b.	Personal Service	3.6	10.4	17.0	25.4	43.6	.404	.752	.268	8472
c.	Knowledge	3.7	11.5	19.4	26.3	39.1	.361	.640	.222	13818
d.	Data	4.6	12.7	19.0	24.9	38.8	.343	.636	.201	11721
e.	Information (= c + d)	4.5	12.7	18.8	25.0	39.0	.345	.638	.204	11863
All	(a + b + e)	4.1	11.7	18.5	25.3	40.4	.365	.678	.226	10820

Table 3.6
Distribution of Annual Income by Occupational Sector - all workers 1981

		Quintile Shares					Gini Ratio	Coefficient of variation	Theil index	Annual income
		1	2	3	4	5				
a.	Goods	5.5	13.6	19.9	25.4	35.6	.304	.540	.159	16067
b.	Personal Service	3.2	9.1	17.3	26.3	44.1	.419	.839	.303	11851
c.	Knowledge	5.6	13.5	19.2	25.3	36.4	.310	.558	.163	20470
d.	Data	4.8	12.2	17.4	24.3	41.3	.362	.701	.224	16939
e.	Information (= c + d)	4.9	12.2	17.5	24.5	40.9	.358	.684	.218	17383
All	(a + b + e)	4.5	12.3	18.3	25.0	39.9	.355	.671	.215	16136

Clearly, such assumptions would represent "large" shifts in the composition of employment, coupled with no balancing impacts of any changes in relative wages. Yet even so, the aggregate inequality in earnings in such a labour force would not be markedly different from that which now prevails in the labour market.

Using the decomposition properties[24] of the Theil index of inequality one can calculate, for example, that under the above assumptions the Theil index of inequality of annual earnings among male Canadian workers would have been .18, rather than the actual value of .16 in 1980 – or about the same as inequality in the personal service sector. Assuming unchanged average incomes within occupational sectors, and the assumed shifts in the numbers employed in each sector, the average income of all workers would increase to $20,332 from the actual 1980 value of $20,086 – clearly a trivial change. Basically, because (1) one of the expanding sectors (personal services) is below-average in earnings while the other expanding sector (knowledge workers) is above average in mean earnings and (2) earnings are very unequally distributed within all sectors, even these large changes in the sectoral composition of the labour force have relatively little influence on the aggregate inequality of individual earnings, or their average level.

Of course, one has to emphasize, in big bold letters, that these sorts of calculations assume away any problems of adjustment and the entire macro-economic issue of aggregate demand. These sorts of calculations are useful *only* as an indicator of the degree of inequality in earnings *if* workers could move easily between sectors and *if* aggregate demand for labour is maintained at approximately its 1980 level. In fact, of course, it is often very difficult – sometimes impossible – for individuals to move between occupational sectors. The assumption of inter-sectoral mobility is basically relevant to the long run, since *entrants* to the labour force flow disproportionately to expanding sectors.

Our data is drawn from the 1980/81 period, prior to the recession of 1981/82 and the decision by Canadian monetary and fiscal policy makers to tolerate unemployment rates of 9% and more following the "recovery" from that recession. I have argued elsewhere (Osberg, 1987, 1988) that high unemployment rates inhibit the intersectoral mobility of labour which is needed to adapt to the "information economy". As well, the earnings determination models and distributions of earnings cited in this chapter are those of 1980/81 – i.e., those of a labour market with approximately 7.5% unemployment. They would undoubtedly be different in a 10% unemployment labour market.

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[24] Define
R = the Theil measure of aggregate inequality,
R_g = the Theil index for intra groups inequality, for group g
Y_g = average income for group g
n_g = number of income recipients in group g
n = total number of income recipients in group g
Y = average income of all recipients
S_g = $n_g Y_g / nY$
R = $\Sigma S_g R_g + \Sigma S_g \ln (Y_g/y)$

see Cowell (1977,165)

Table 3.4A
Distribution of Annual Income by Occupational Sector - Canadian Males 1981

		Quintile Shares					Gini Ratio	Coefficient of variation	Theil index	Average income
		1	2	3	4	5				
a.	Goods	6.9	14.8	20.3	24.5	33.3	.27	.508	.13	17851
b.	Personal Service	5.3	13.5	19.5	25.2	36.7	.31	.542	.16	15669
c.	Knowledge	7.6	14.1	18.9	23.1	36.3	.27	.526	.13	26319
d.	Data	6.8	13.7	18.2	22.6	38.7	.32	.645	.18	18927
e.	Information (= c + d)	6.8	14.2	18.0	24.0	37.0	.30	.584	.16	23462
f.	All (a + b + e)	6.8	13.7	19.0	23.7	36.8	.31	.582	.16	20086

Table 3.5A
Distribution of Annual Income by Occupational Sector - female workers 1981

		Quintile Shares					Gini Ratio	Coefficient of variation	Theil index	Average income
		1	2	3	4	5				
a.	Goods	4.5	12.0	18.5	25.3	39.7	.353	.641	.209	8309
b.	Personal Service	3.6	10.5	17.0	25.3	43.6	.404	.792	.277	6875
c.	Knowledge	4.4	13.0	20.2	25.9	36.5	.324	.584	.185	15632
d.	Data	4.9	13.3	19.7	25.2	36.9	.323	.597	.182	10566
e.	Information (= c + d)	4.6	12.7	18.9	25.0	38.8	.342	.630	.199	11926
f.	All (a + b + e)	4.1	11.7	18.5	25.3	40.4	.365	.678	.226	10820

Table 3.6A
Distribution of Annual Income by Occupational Sector - all workers 1980

		Quintile Shares 1	2	3	4	5	Gini Ratio	Coefficient of variation	Theil index	Average income
a.	Goods	5.5	13.6	19.9	25.4	35.6	.304	.540	.159	16067
b.	Personal Service	3.0	8.6	17.0	27.1	44.3	.423	.764	.296	10970
c.	Knowledge	6.1	13.8	18.8	24.5	36.8	.307	.570	.162	22518
d.	Data	4.8	13.0	18.0	23.9	40.3	.349	.725	.220	13276
e.	Information (= c + d)	4.9	12.1	17.5	24.4	41.1	.362	.696	.222	17304
f.	All (a + b + e)	4.5	12.3	18.3	25.0	39.9	.355	.671	.215	16136

Nevertheless, although high unemployment exacerbates the personal and economic problems of workers displaced from contracting sectors and inhibits voluntary labour mobility, there is still some point in distinguishing between the implications of long-run structural change in the economy and the implications of the current high unemployment policy.[25] It is true that job loss in a high unemployment economy entails considerable difficulties in locating new employment. But the expanding personal service sector requires relatively little in educational credentials or employment experience. Were aggregate demand greater, the number of jobs available in that sector would also be greater. But such jobs are not being created at a fast enough rate to produce "full employment", in part because of fears of rekindling inflation and in part because employment in many personal service occupations (e.g. nursing) is concentrated in the public sector, expansion of which may be constrained by worries about government deficits. Hence the issue is not whether people have the skills that the jobs of the future will require – rather the issue is at what rate those jobs will be created.

3.6 Conclusion

To conclude, the labour force can be divided into two broad types of occupations, those involved in the production of information and those involved in the production of goods and personal services. In all occupational groups, there is some individual return to attaining a minimum norm of education (high school graduation). In the information sector, post-secondary and post-graduate education is strongly rewarded, but in the non-information sector there is no payoff to further education.

Over time, the asymptotic stagnancy argument implies that knowledge occupations, which have the greatest absorption of college and post-graduate trained workers of any category, will grow in relative importance. Some of the policy issues which this trend raises will be discussed in Chapter 4. Here we note that the *combined* influence on aggregate inequality of annual income of a shift from goods to personal services *and* from data to knowledge production is likely to be rather small. To some extent, these trends will, in the long run, balance each other and, in any event, most of the inequality in annual income is due to dispersion in earnings *within* occupational categories.

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[25] A more polite commentator might say that the goal of deficit reduction has taken precedence in fiscal policy and that monetary policy has been oriented to exchange rate stability and the prevention of inflation.

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Appendix A

Heckman (1979) has outlined a methodology, which has by now become rather standard, to test, and to correct (if necessary), for sample selection bias. The basic sample selection bias problem involved here is that one observes in Census data the income that an individual actually received in 1980 and the occupational group to which they belonged. However, one does not observe the income that they could have obtained in an alternative occupation. If the prediction errors in the equation which determines choice of occupation are correlated with the prediction errors in the equation which predicts income within an occupation, ordinary least squares regression results will be biased. The Heckman methodology tests for this bias by predicting, using a probit regression, the probability with which an individual will belong to a particular category. From that regression, one can calculate a sample selection bias correction term[26] which is included in an ordinary least squares regression. If, in this case, the sample selection bias correction term (labelled Lambda in Tables A(2) and A(3)) is statistically insignificant, the conclusion is that sample selection bias is empirically insignificant in this application.

On the basis of Tables 3.1 to 3.3, one can argue that occupations in the information sector, both in knowledge, production and data generation, are occupations in which there is a positive rate of return to years of education. On the other hand, personal service and goods based occupations are similar in that education is not rewarded in either. Hence, a discussion of sample selection bias in the estimation of earnings functions within occupational categories can proceed by analysis of the probability of membership in two broad classes of occupations – information workers and non-information workers.

However, even with such broad categorization, it is clear that if we are to assess, adequately, the problem of sample selection bias, we need a wealth of detail on individual respondents that is simply not present in Census data. Unfortunately, the use of alternative data sources inevitably implies smaller samples for estimation. Diminished sample size is very important when we wish, as in Tables 3.1 to 3.3, to assess the relevance of *particular* levels of educational qualifications for labour earnings within occupational categories (rather than using years of education as a single continuous variable).[27]

To assess the potential importance of the sample selection bias issue, we therefore use a data set derived from a series of surveys carried out by the Institute of Public Affairs at Dalhousie University during 1979 and 1981. In 1979, a stratified random sample of 118 private sector establishments provided lists of all workers employed at those establishments. From the worker lists, which included all employees save the top manager, a random sample of 2,069 names was drawn. These workers were interviewed by telephone, with a response rate of 73.5%, in 1979 and again in September 1981, when 1,124 usable responses were obtained from those who had cooperated in the first wave of interviews. As part of both the 1971 and 1981 interviews, respondents were asked for information on current employment wage rates, attitudes to current job, previous year's total income, personal characteristics (including father's age and occupation) and characteristics of other household members.[28]

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[26] Often called the "inverse Mills ratio" or the ratio of the probability density function to the cumulative density function of a standard normal variate, as implied by the probit model.

[27] In census data, although the *proportion* is small we do observe a number of people with advanced degrees in the non-information sector (since the sample is so large). In other data sets, such observations are infrequent.

The advantage of this data set is its wealth of detail on each individual respondent, which enables us to examine in some depth the determinants of the probability of belonging to the information sector. The disadvantage of this data set is its sample size, which imposes the necessity of treating education as a continuous variable, since insufficient observations are available on each particular level of educational attainment, within occupational categories.[29]

Table A1 presents our results on the determinants of the probability that individuals will work in the information sector. We start (Probit 1) with a fairly catholic list of regressors which might predict occupational position. Not surprisingly, years of education are a significant determinant of the probability that males will enter the information sector. (For females, the effect is not significant, doubtless reflecting the greater weight of data processing among female workers). Those whose first job was in the information sector, and who are of English ethnic origin are more likely to be in information based occupations. Seniority with current employer also correlates with occupational classification.

Since the dependent variable in Table A1 measures only whether the individual had an information based occupation in 1981 and since such occupations span a wide range of occupational statuses, it is perhaps not surprising that *Blishen scores* which measure the occupational status of the respondent's first job or their Father's occupation are statistically insignificant. It is, however, noteworthy that the education and type of occupation of the respondent's father (information/goods-service) are not statistically significant either. Neither does illness or problems with physical health correlate with occupational sector. Nevertheless, despite the fairly large number of statistically insignificant variables, those remaining predict correctly 76% of classifications for males (78% for females).

With a more restricted set of regressors, as discussed above, the columns headed "PROBIT2" necessarily produce a somewhat poorer prediction. Indeed, for females the probit model fails a likelihood ratio test at 15%, while for males only ethnic origin and sector of first job are statistically significant. Nevertheless, for males, 71% of classifications are correctly predicted and the Chow R square is .65 for males under PROBIT2.

The point of Table A1 is, however, only to make it possible to include a correction for sample selection bias in earnings equations such as those reported in Table A2 And the point of Table A2 and A3 is simply that such a correction term is statistically insignificant, either calculated from PROBIT1 or from PROBIT2.

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[28] This data set is more fully described in Osberg (1986) and Apostle (1980).

[29] Hence, for example, statistical significance for "years of education" when one examines male workers in service occupations will be picking up the differential between the earnings of those with 9 to 11 years of education and those with high school graduation. One cannot examine separately the payoff to post-secondary education (as in Tables 3.1 to 3.3) since too few cases are observed in the data.

Of course, the earnings determination process can be examined in greater detail with this data set (see Osberg 1986). And a larger data set (such as the Census) would enable us to get behind the statistical significance of education in Table 3.5 (i.e. over the range of values sampled in the IPA data) to discover *which levels* of education are significant determinants of earnings, and which are not, within occupational sectors. But at least Tables A2 and A3 gives us no reason to suspect that sample selection bias is driving the results reported in Tables 3.1 to 3.3.

Table A1
The Probability of an Information Sector Job

	Males		Females	
	Probit 1	Probit 2	Probit 1	Probit 2
YEARS SCHOOLING	.195 * (4.76)		-.1694 (-.98)	
LENGTH	.00354 * (3.35)		.0155 * (3.24)	
TRAIN	-.00019 (-1.20)		.00185 ' (2.04)	
ILL79	-.269 (-.71)	.138 (.39)	.973 (1.46)	-.157 (.35)
ILL81	-.157 (-.62)	.027 (.12)	.745 (1.18)	.4058 (.71)
MARGIN79	.885 * (4.04)		1.255 ' (2.40)	
NOTANG10	-.914 * (-3.53)	-.780 * (-3.23)	-.282 (-.41)	-.442 (-.92)
FATHERS SCHOOLING	-.0149 (-.94)	-.00031 (-.02)	.00907 (.36)	-.01002 (-.41)
FATHERS STATUS	-.0014 (1.41)	.0011 (1.23)	-.00204 (-.90)	-.000016 (-.009)
START STATUS	-.00079 (.84)	-.00137 (-1.56)	.00257 (.82)	-.00215 (.93)
FATHERS SECTOR	.183 (.64)	.383 (1.47)	-.259 (-.36)	.0581 (-.11)
START SECTOR	.579 ' (2.55)	.625 * (2.90)	2.741 * (2.77)	1.102 · (1.88)
CONSTANT	-2.311 ' (2.37)	-.692 (-.81)	-4.939 · (-1.68)	-1.081 (-.58)
Log-Likelihood	-130.87	-151.83	-37.27	-50.79
Likelihood/Ratio Test	75.09	33.18	36.13	9.077
N	254		91	

* significant at 1%
' significant at 5%
· significant at 10%
T- statistics in brackets

Table A2
Earnings Determination - Males

		Non info			Info	
	01S	SS1	SS2	01S	SS1	SS2
SCHOOLING	.0348 * (3.07)	.0343 * (2.61)	.034 * (2.99)	.018 * (2.64)	.025 ' (2.34)	.0181 * (2.60)
EXP1	.0155 ' (2.05)	.0156 ' (2.03)	.016 ' (2.12)	.0315 * (4.57)	.0303 * (4.29)	.0316 * (4.39)
SEXP1	-.00018 (-1.46)	-.00018 (-1.45)	-.00019 (-1.54)	-.00066 * (-5.46)	-.00064 * (-5.17)	-.00066* (-5.27)
LENGTH	-.00047 ^ (-1.74)	-.00048 (-1.56)	-.00049 ^ (-1.81)	.00017 (.57)	.00028 (.83)	.00017 (.56)
TRAIN	.00006 (1.48)	.00006 (1.48)	.00006 (1.46)	.00011 * (3.79)	.00011 * (3.66)	.00011* (3.61)
ILL81	.012 (.23)	.012 (.23)	.022 (.42)	.0425 (.67)	.0566 (.87)	.042 (.66)
UNEMP81	-.825 * (-3.91)	-.827 * (-3.88)	-.836 * (-3.96)	.313 ' (2.11)	.321 ' (2.15)	.312 ' (2.06)
HOURS81	.00245 (.69)	.0025 (.69)	.0024 (.69)	.0115 * (3.73)	.0116 * (3.75)	.0116 * (3.65)
WEEKS80	.0098 * (4.01)	.0098 * (3.98)	.0099 * (4.04)	-.0022 (-1.48)	-.0022 (-1.48)	-.0022 (-1.46)
PENSION	-.0107 (-.25)	-.011 (-.26)	-.0145 (-.34)	.0427 (.99)	.0424 (.98)	.0423 (.96)
SECMOVER	-.274 * (-4.77)	-.277 * (-3.96)	-.278 * (-4.82)	-.104 ' (-2.13)	-.071 (-1.13)	-.104 ' (-2.12)
CHANCES	-.044 ^ (-1.90)	-.044 ^ (-1.899)	-.044 ^ (-1.89)	-.0623 * (-2.77)	-.0647 * (2.85)	-.0622 * (-2.72)
LAMBDA		-.017 (-.08)	-.159 (-.87)		-.164 (.84)	.00737 (.04)
CONSTANT	9.86 * (41.5)	9.89 * (23.1)	10.07 * (29.9)	8.86 * (53.1)	8.96 * (43.2)	8.85 * (31.3)
$\bar{R}^2$	.30	.29	.30	.69	.69	.69
N	158			96		
F	6.51	5.97	6.06	18.94	17.47	17.27

* significant at 1%
' significant at 5%
^ significant at 10%
T- statistics in brackets

Table A3
Earnings Determination - Females

	Non info			Info		
	0LS	SS1	SS2	0LS	SS1	SS2
SCHOOLING	.0651 *	.042	.059 ˆ	.0322 ˆ	.029 ˆ	.0305 ˆ
	(3.13)	(1.10)	(1.88)	(1.74)	(1.71)	(1.69)
EXP1	.00861	-.00016	.0045	-.0053	-.0109	-.0068
	(.39)	(-.006)	(.16)	(-.55)	(-1.22)	(-.72)
SEXP1	.00065	-.00063	-.00059	.00013	.00021	.00012
	(-1.34)	(-1.28)	(-1.08)	(.65)	(1.15)	(.61)
LENGTH	.00397*	.0034 '	.004 *	.000197	-.0002	.0003
	(3.62)	(2.54)	(3.51)	(.34)	(-.36)	(.53)
TRAIN	.00047	.00036	.00048	.000098	.00003	.000097
	(1.53)	(1.03)	(1.48)	(1.31)	(.48)	(1.33)
ILL81	-.0304	.152	.0096	.157	.258 '	.204 ˆ
	(-.19)	(.51)	(.04)	(1.48)	(2.53)	(1.93)
UNEMP81	.0515	-.014	.067	-.408 *	-.397 *	-.341 '
	(.24)	(-.06)	(.29)	(-2.74)	(-2.92)	(-2.30)
ILL81	.0294 '	.025 ˆ	.0286 '	.00093	.0079	.0055
	(2.91)	(2.07)	(2.599)	(.09)	(.82)	(.54)
WEEKS80	-.00048	-.00104	-.00068	.003	.0025	.0026
	(-.24)	(-.48)	(-.31)	(1.58)	(1.42)	(1.39)
PENSION	-.123	-.023	-.094	.155 *	.213 *	.190 *
	(-.97)	(-.12)	(-.54)	(2.82)	(4.01)	(3.39)
SECMOVER	-.174	.275	-.178	-.240 *	-.234 *	-.197 *
	(-1.61)	(-1.55)	(-1.58)	(-3.32)	(-3.54)	(-2.68)
CHANCES	-.124	.190	-.135	-.058	-.050	-.0495
	(-1.58)	(-1.56)	(-1.45)	(-1.50)	(-1.42)	(-1.32)
LAMBA		-.327	-.108		.695 *	.710 '
		(-.72)	(-.25)		(3.33)	(2.05)
CONSTANT	7.78 *	8.99 *	8.05 *	9.32 *	8.18 *	8.15 *
	(13.58)	(5.03)	(6.64)	(18.4)	(14.2)	(10.85)
$\hat{R}^2$	.81	.80	.80	.54	.61	.56
N	27			64		
F -	10.17	9.11	8.77	7.05	8.64	7.23

* significant at 1%

' significant at 5%

ˆ significant at 10%

T- statistics in brackets

Tables A1 to A3 Variable Definition

LENGTH	months with current employer (1981)
TRAIN	time to fully learn current job (1981)
ILL79	Have you ever lost a job or had to change jobs because of illness or other physical disability? (1 = yes)
ILL81	Have you had any problems with your health that have affected your work like in the last 2 years? (1 = yes)
MARGIN79	employed at marginal employer in 1979 (for definition see Osberg 1986).
NOTANG10	ethnic origin
FATHERS STATUS	Blishen score of Fathers "main occupation".
START STATUS	Blishen score for respondent's first job.
FATHERS SECTOR	sector of respondent's father's main job. 1 = Knowledge/Data 0 = Goods/Service
START SECTOR	sector of respondent's first job.
UNEMP81	unemployed in past 2 years (1981). (1 = yes)
HOURS81	hours worked in average work week.
WEEKS80	weeks worked in 1980.
PENSION	presence of employer paid pension
SECMOVER	= 1 if marginal worker 1979 and changed employers 1979-1981.
CHANCES	"For the average person does your kind of job lead to a better job in future? Always = 1 Usually = 2 Sometimes = 3 Never = 4
EXP1	Age - Schooling - 5
SEXP1	$(\mathrm{EXP1})^2$

Table A9

Educational Attainment by Occupational Sector - Canadian Males 1981

	Data	Knowledge	(Information)	Goods	Personal	All
Less than 9	.072	.031	.047	.222	.205	.143
9 to 11 years	.176	.068	.110	.208	.182	.164
H.S. Grad	.324	.173	.231	.202	.250	.219
TRADES	.183	.193	.189	.309	.243	.243
University – Non-Grad	.135	.143	.140	.047	.080	.092
B.A. Grad	.069	.235	.171	.01	.033	.085
Post-Graduate	.041	.157	.112	.002	.007	.054
% of all males	18.4%	29.2%	(47.6%)	43.4%	9.1%	100%

Educational Attainment by Occupational Sector - Canadian Workers 1981

	Data	Knowledge	(Information)	Goods	Personal	All
Less than 9	.061	.026	.045	.230	.217	.125
9 to 11 years	.154	.063	.114	.206	.212	.158
H.S. Grad	.345	.156	.262	.207	.253	.244
TRADES	.246	.177	.215	.289	.219	.234
University – Non-Grad	.118	.159	.136	.053	.075	.102
B.A. Grad	.050	.261	.142	.012	.021	.087
Post-Graduate	.025	.157	.083	.004	.002	.049
% of all workers	33.4%	25.8%	(59.2%)	29.3%	11.4%	100%

Chapter 4

Selected Policy Issues

Lars Osberg

Chapters 1 to 3 have stressed two fairly controversial themes as the basis for analysis of the information economy. In chapter 1, and in the empirical work of chapter 2, we have stressed the unbalanced nature of employment growth in modern capitalist economies – in particular, the tendency for workers in knowledge based and personal service occupations to increase their proportionate importance in the labour force over time. Chapter 2 emphasizes that the increase in employment in the information sector over the period 1960 to 1980 has been very rapid, in both absolute and relative terms. The dominant factor in this employment growth has been a shift in the composition of employment within industries, which particularly favours knowledge workers. Within the non-information sector employment in personal services occupations has gained dramatically at the expense of employment in goods producing occupations. This focus on qualitatively different *types* of occupations, and the emphasis on unbalanced employment growth in the long run, represents a distinct contrast to the models of balanced growth common in the economics literature.

These distinctions between *types* of occupations and a forecast of differing future rates of employment growth would not matter much if the earnings determination process was the same in all occupational categories. Chapter 3, however, argued that there are significant differences, by occupational category, in the earnings determination process. Education, and particularly post-secondary education, is a significant determinant of earnings in the information sector but not, beyond a basic minimum, in the goods or personal service sector. This finding is in distinct contrast to models of earnings determination in the "human capital" research tradition such as those of Mincer (1974) or Willis (1986) which start from the supposition that an economy wide market exists for general human capital. Chapter 3 did argue, however, that the combined influence on aggregate economic inequality of intersectoral shifts in employment is likely to be small. We find no grounds to support the "disappearing middle" hypothesis that technical change will polarize the income distribution (see also Leckie, 1987).

Our hypothesis of asymptotic stagnancy within the information sector and unbalanced growth between goods and personal service occupations does raise a number of policy issues. The primary issue is implicit in our basic model – we see no reason to be concerned about "deindustrialization" in the sense of an increasing employment share of services (broadly defined). Although it is sometimes said (e.g., CEIC, 1986:16) that the service sector needs a "healthy" goods producing sector, such "health" is not to be equated with numbers employed and certainly not with numbers employed in any particular country.

In the "deindustrialization" debate one often observes the attitude that real wealth is created when goods are produced, and the service sector is, in a sense, parasitic. We cannot resist observing the similarities between this attitude and the position of the "Physiocrat" economists of eighteenth century France, who believed that all wealth originated in agricultural production. Agriculture is still the only sector where one actually observes the *growth* (as opposed to the transformation) of commodities, but major food exporters like the U.S. and Canada manage quite nicely with less than 4% of their labour force in agriculture. Furthermore, as we will emphasize below, information is an internationally tradable commodity. Although information can be seen as an indirect input into goods production, in a global economy there is no reason to expect, or to desire, that some areas of the world will not specialize in the production of information.

The transition to an economy dominated by the production and distribution of information has been underway for several decades, and will undoubtedly continue for several more. This transformation of productive activity, and its asymptotic stagnancy, is certain to affect many aspects of society, and the implications of these changes will take a long time to work themselves out. The shift of employment into the managerial/ professional/ technical group of occupations is, for example, occurring simultaneously with a "flattening" of organizational pyramids, as corporations and governments find that new information technology enables them to dispense with several layers of middle management personnel, whose functions, it turns out, were always fairly routine. And one could go on to cite the changes in popular culture that come with global broadcasting or the political implications of the decreased cost of polling as issues which have also been created by the declining relative cost of data production within the information economy. As a result, a concluding chapter on "policy issues" has the potential to be rather long – so to keep things manageable, we will focus on three issues: education, research and development, and international trade.

4.1 Education

If one accepts the idea that the information economy will continue to grow in relative importance, the education sector will be subject to particular stress. The education sector interacts with the information economy as both a producer and as a consumer of information workers, as a direct producer of information and a repository of knowledge. Furthermore, both the demands placed on the education sector and the policies which governments use to affect it are far from one-dimensional. The education sector is deeply affected by a range of public policy interventions, from taxation to research funding, and is expected to contribute to the attainment of a diverse range of public policy objectives – including but not limited to, social equity, economic growth and the promotion of culture.

The education sector is the direct employer of knowledge workers (such as professors) and as such can be seen as a major consumer, in its own right, of information labour. Indeed, the education sector is a classic example of asymptotic stagnancy in production. Despite the occasional success of experiments in new educational technology (such as the Open University of the UK), and despite the spread of a few technical innovations (such as overhead projectors), the overwhelmingly dominant technology in the education sector remains virtually the same today as in the middle ages. In the 1980s, as for centuries before, the basic technology of production in the education sector is the personal interaction of an instructor and a classroom of students. When compared to the technical change which has occurred in other sectors (e.g., chemicals, transportation) technical change in education is pitifully small.

The basic factor which has militated against fundamental technical change in education is the non-routine nature of information transferal between people, as compared to the routinization possible when information is transferred between machines.[1] Students are never quite identical and their problems in comprehension, their questions and their speed of learning are never quite the same. Although it is possible to write one algorithm which will transfer information from one computer to another, and the same programme will work for all comparable makes of computer, it is not yet possible to write standardized teaching packages which will adequately convey the content of most academic courses.

Although the lack of change in instruction methods in education is sometimes decried as evidence of a lack of "progressive thinking" among educators, this criticism really misses the point. The vast majority of participants in any industry, at any time, are never "progressive thinkers", but technical change is forced on everyone in the industry by the evident superiority of new methods of production initiated by a few creative entrepreneurs – as occurred, for example, when railways replaced canals as a method of transportation of goods. The important fact is that humans have not, in the several centuries in which systems of formal education have been in existence, found a method of education which is unambiguously superior to the personal interaction of teachers and groups of students. Currently, experiments are under way to produce teaching programmes for courses with unambiguous cognitive content (such as statistics), and one may see, in the future, progress with artificial intelligence based teaching programmes. At the moment, however, we feel it appropriate to classify teachers as mostly "knowledge" workers, since the interaction of teachers and students is never quite routine.

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[1] For some years there have been experiments with computer based learning systems and in some applications (e.g., flight simulators) they are now routine. Yet among the millions of students now enrolled in everything from grade one to advanced chemistry, the basic structure is still a teacher, a text and a classroom. In part the historic technology of printed textbooks may retain its market position because the royalties of authors are protected by the difficulty and expense of copying textbooks – unlike software, which is so easily pirated (see below). But this cannot be a complete explanation since large consumers of textbooks (e.g., the school system of California or that of the U.K.) should be able to internalize any savings involved in computer based instruction.

Furthermore, within the university sector, the professoriate are expected to be both teachers and researchers – i.e., to both transmit information in a non-routinized way and to create new knowledge (in particular, new *published* knowledge). We therefore see little prospect for labour productivity in the teaching and research functions of the education sector to increase as rapidly as labour productivity in data or goods production. As a result, the education sector is directly exposed to the cost pressures of an asymptotically stagnant sector (see Ryan, 1987).

The education sector also produces the information workers who are absorbed in other parts of the information economy. As chapter 3 indicated, educational credentials are rewarded in information based occupations, although not in goods production or in personal service occupations. Chapter 3 also indicated that the rewards to education occur both because educated workers give better answers to queries for information and because their answers are believed. Education, in short, indicates possession both of cognitive skills and of credentials – both of which are socially productive.

Public intervention in education is ubiquitous. In all developed countries, the funding and curriculum of primary and secondary education are public responsibilities. Post-secondary education, in most OECD countries, is also publicly financed and publicly controlled, although within a wide variety of institutional mechanisms. Although the United States has a large "private" component in post-secondary education (as the UK has for secondary education) the survival of this sector is crucially dependent on government funding for research, assistance to student finances and on "tax expenditures" in the form of the tax deductibility of tuition, and the tax treatment of the endowments of private colleges.

As chapter 3 indicated, there are some grounds for believing that the attainment of a minimum norm of education is important for earnings determination in all sectors of the modern economy. The *distinguishing* characteristic of the information economy, however, is the importance of post-secondary education to earnings attainment. And over the 1970's the shift in job structure towards jobs requiring post-secondary education has been quite dramatic. In Canada, the net impact of changes in the education mix within occupations, occupation mix within industries, average labour productivity, intermediate demand and pattern of final demand would have produced a decline of 72.4% in the employment of those with less than grade 9 education but the 39.1% increase due to increases in final demand somewhat balanced that, for a net decline of 33.3%. For those with some university education, the shifts in educational mix, occupational mix and pattern of final and intermediate demand were all positive, and the aggregate effect (including the increase in final demand) was a net increase of 66.9% in employment (ECC, 1987: 152).

Since the "information economy" is growing in relative importance, and is characterized by substantial returns to post-secondary education, it follows that the social mechanisms which determine the amount and type of post-secondary education are also increasing in social importance. Across nations one observes a wide variety of institutional forms of organization of post-secondary education.

In the United States, state governments finance a wide range of post-secondary institutions, from small community colleges to large universities with major graduate programs, which co-exist with a significant non-government sector, financed by tuition payments and endowments. No national control is exercised on the offerings of post-secondary education, and its aggregate size is "student driven" – there is always a place, somewhere, for a student who meets minimal entrance requirements in the specialty of his/her choice.

In Canada, although university education is delivered by "private" institutions, these institutions are largely dependent on government financing, usually paid as a weighted function of student enrollment. Informal pressure can be exerted at the provincial level to prevent the expansion, or to influence the contraction, of the number of places available in particular degree programs[2] but there is no national allocation of priorities within the post-secondary education system. For the most part, enrollments are essentially "student driven", with universities accepting all applicants whose academic qualifications exceed some minimum entrance requirement.

The implication of the Canadian system, where the revenue of each university is dependent on enrollment (partly directly through tuition payments and partly indirectly through per-student grants), is that universities compete with one another for enrollment and for revenue. If the aggregate amount of government financing is fixed, this implies that admissions by each university have externalities for other universities, in that greater enrollment at competing institutions will decrease the grant *per student* for all universities. Since no institution has a reason to recognize the losses which its own increases in enrollment will imply for competing institutions, each institution may end up with lower resources, per student, than would be academically desirable, i.e., overexpansion may be "financed" by a diminution in academic quality.

Perhaps because of fears of this sort of outcome, the United Kingdom has opted for much more direct central control of the university system than is prevalent in either the US or Canada, combined with much deeper budget cuts. The aggregate amount of funding, and its allocation among institutions, is centrally determined by the University Grants Council – which also sets the number of places to be offered at each institution. The allocation of this fixed number of entrance places to individuals is determined by relative academic qualifications – in effect the entrance qualification varies to equilibrate the supply and demand for seats in post-secondary institutions – but the size of the sector in aggregate is set by administrative fiat, not by the decentralized decisions of individuals. In effect, since the number of places available falls far short of student demand (i.e., the entrance requirement has been increasing) the U.K. is running a massive experiment in manpower planning whose premise is the "over-supply" of university trained manpower (especially in the humanities and social sciences). Our model of the information economy directly contradicts this premise.

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[2] For example, provincial governments in Canada have been relatively successful in limiting enrollments in medical schools (no doubt because provincial governments feel the pressures of increasing medical costs and the medical profession is concerned about the impact of major increases in supply on physicians earnings). Canada does not seem to be facing the same degree of emerging over-supply of physicians as the U.S.

Thus, even among the US, the UK and Canada, whose academic institutions otherwise have so much in common, there is a wide variation in the institutional mechanisms which govern enrollment in, and funding of, post-secondary education, and which determine the relative emphases within post-secondary education. There is great variation, as well, in the non-university post-secondary sector, and the picture would become even more variegated still if one were to consider as well the institutional arrangements of continental European nations.

The emerging importance of the information economy raises a whole thicket of issues for the education sector, and in particular for the post-secondary education sector. As we have noted, there are a variety of ways of organizing the post-secondary sector, and such institutional arrangements can be expected to have significant impacts on its size and nature. But which institutional mechanisms are most appropriate? How deeply should the public sector be involved in the decision making, and the funding, which surrounds the post-secondary education sector? How much attention should universities pay to demands for "relevance" to labour market demands? Is the major purpose of university education the economic advancement of its students or are broader cultural and social values also important? To what extent should notions of economic efficiency be subordinated to considerations of equality of opportunity?

As well, we need to know which *type* of post-secondary education is most appropriate for the information economy. Some would argue for a general, humanist education which is integrative of academic disciplines - others argue for early specialization. Should this education, whatever it is, be delivered in a university with a strong research focus, in primarily undergraduate colleges, in a technical college, or in apprenticeship/internship programmes in industry? Our discussion in Chapter 3 emphasizes the dual function of education in providing cognitive skills *and* in creating credentials. If knowledge must be believed to be true before it can be usefully applied, then "credentialism" has some social value – implying that the technical efficiency of the learning process is not the only consideration in educational reform. In addition, the traditional aim of universities has been to awaken the intellectual capabilities of their students, to create the ability to produce "knowledge", but the role of polytechnics and community colleges has emphasized more heavily the transmission of cognitive information – "training" as opposed to "education". Which emphasis is appropriate? What sort of institution can best balance these objectives? How can the post-secondary system best serve the need for "life-long learning" of an aging population and a technologically dynamic economy?

The depth of these issues insures that they may never, in some fundamental sense, be adequately resolved. But the importance of public funding to post-secondary education ensures that, in a concrete sense, some resolution of these issues is implicitly made each fiscal year.

Confronted with increased demand for places in post-secondary educational institutions, but convinced of the necessity to restrain aggregate expenditures, the policy response of governments in OECD nations has been to cut per capita levels of funding for post-secondary education. Table 4.1 is taken from Ryan (1987) and illustrates the pervasive decline in the funding of both current and capital expenditures in the post-secondary educational sector. On average, the OECD nations as a whole have decreased capital expenditures per student in real terms by 50% and current expenditures per student by roughly 10%. And one must emphasize that the relative unit cost of production, in an asymptotically stagnant sector such as education, tends to increase over time, – i.e. costs are going up while funding is going down.

Although the perspective of this volume is long-term, in that we emphasize a long-run tendency to increased employment in personal services and knowledge production, actual policy initiatives must account as well for shorter term influences. The post-secondary education sector is not now in an "equilibrium" situation, since it expanded rapidly in most nations in the 1960s, prior to the financial contraction of the 1970s. As a result, cohorts of workers now entering the labour market have significantly more years of education than their elders. Even if the size of the post-secondary education system remains unchanged, the average education of the labour force of OECD nations will continue to increase for some time, since new entrants have more years of education than retirees.

Whether years of education still mean the same in "quality" terms is less easy to say, given the funding cuts documented above. Furthermore, as the OECD puts it; "the appointment of large numbers of (mostly young) professional staff in the 1960s, followed by an abrupt drop in recruitment in the 1970s, produced an age structure in which most of those conducting long-term research are now in their late 30s or 40s. This bulge, although aging year by year, will remain in the national systems for 20 or 30 more years. At the same time, the abnormally low proportion of faculty members at the upper end of the age scale, the 51 to 60 year old bracket, will mean that relatively few vacancies will be created by retirements during the next five to fifteen years." (OECD, 1985: 46)

This problem of an unbalanced age structure in post-secondary education, is one that is common throughout OECD nations – the OECD notes, for example, that only 158 French academics from a total of 44,000 were expected to retire in 1983 (a vacancy rate of only 0.3 percent) while in Germany the vacancy rate is expected to be between 1 and 2 percent for the rest of the decade. In the short-term, this creates problems of unemployment of new graduates and of maintaining the vigour of intellectual life in universities. In the longer term, there will be a problem of replacement, when the dominant cohort of the professoriate simultaneously retire, in the period after the turn of the century.

Table 4.1
Enrollment and Funding Trends in OECD Nations

	Changes in Real Capital Outlays and Enrollments in Public Postsecondary Education: OECD Economies, 1970-82		
Country	Change (1970/2-1980/2) in		Real Public Current Expenditure per Full Time Student (1974=100)
	Real Gross Capital Expenditure[1]	Enrollments[2] % increase	
Austria	-12.7%	112.4%	80.3
Canada	-39.0	42.7	79.0
Denmark	n.a.	24.8	75.5
Finland	39.0	103.2	102.0
France	-73.3	34.7	92.7
Germany	-50.9	124.8	63.9
Ireland	114.1	95.2	113.2
Italy	73.4	36.4	82.9
Japan	42.6	25.9	124.0
Netherlands	-35.0	51.6	80.3
New Zealand	-40.1	20.6	81.0
Norway	-26.7	50.0	120.3
Sweden	n.a.	50.5	54.5
Switzerland	-24.1	63.4	93.5
United Kingdom	-43.6	39.4	76.7
United States	-36.2	38.4	94.4
All (ex USA)3,5	-20.0	43.4	85.9
All (inc USA)3,5	-29.3	39.8	91.6

Source: (Ryan, 1987)

Notes:
1. Deflated by GDP deflator.
2. Full-time and part-time enrollments.
3. Denmark, Netherlands, New Zealand and Sweden excluded from aggregates as a result of gaps in data.
4. Deflated by price index for higher education (or all education or public services, when not available).
5. Averages of national values, weighted by constant (1974) dollar equivalent outlays (at midyear spot exchange rate); New Zealand excluded due to gaps in data.

As well, the uneven nature of expansion within the post-secondary education sector has meant that the physical infrastructure now in place has largely become obsolete. The OECD emphasizes the similarity across countries of problems in post-secondary education which have been caused by the collapse of post-secondary educational funding in the 1970s. In many ways, the magnitude of the problems caused by under-funding dominates the problems of the organization of funding and the intra-sectoral allocation of resources. If our model of an expanding information sector and the increasing relative importance of knowledge workers is true, then under-funding on this scale represents a massive refusal to face the structural trends of the modern economy.

4.2 Research and Development

Direct encouragement of "research and development" remains a subject to which the governments of all OECD nations pay regular lip service – but what exactly is this "R&D" which everyone is in favour of?. In the context of this volume, it is worth stressing that our concept of "knowledge" as non-routine information is much broader than the *types* of knowledge production normally labelled as "research and development". Hardly anyone, for example, counts the market research of advertising agencies and the production of their advertisements as "research and development", yet most of the labour involved in this activity does represent the creative manipulation of information. The term "knowledge" may sound a little grandiose when applied to the work of advertising agencies, but what we wish to draw is a distinction between creative and non-creative information production – and advertising agencies are undeniably creative. Similarly, we would classify the performing arts, including actors, writers and directors in movies and television, as "knowledge" workers – and we note that over time the payroll costs of creative workers in film production have risen steadily as a fraction of production costs, as one would expect in an asymptotically stagnant sector (see Baumol, Blackman and Wolff, 1985).

The direct production of knowledge blends issues of institutional and financial policy. Rapid increase in the efficiency of data transmission implies that new knowledge can be quickly replicated at progressively lower costs, thereby accentuating the problem that such knowledge may be a "public good". And the historic problem with public goods is that few are willing to produce them because charging consumers for their access is not technically feasible.[3] Since the benefits of the use of a public good can be easily appropriated by those who did not pay for its production, such goods tend (unless subsidized) to be under-produced in a market economy.

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[3] The rapid international emulation of innovations in production technology is one example (see OECD, 1985) but a more specific example is the controversy over digital recording technology and audio tapes. As the technology of sound reproduction has improved, the costs of obtaining a virtually perfect copy of a creative musical performance have diminished correspondingly, creating new problems of protecting copyright, i.e., the market mechanism for payment for production of creative audio information no longer works very well. Similarly, the ease with which educational software can be copied means fewer royalties are paid to its authors – hence there is less incentive to individuals to write software for computer-based instruction.

A full discussion of the problems involved in the definition and protection of rights to intellectual property would take us far afield, since the controversy extends from issues such as payment for the xeroxing[4] of journal articles to satellite transmission and the international capture of TV signals. We emphasize, however, that the common element in these controversies is the decreasing cost of reproduction *relative to* the costs of creation. The production of a book, or a musical recording, or a movie involves both a creative activity (which we refer to as the production of "knowledge") and the reproduction of that activity in some format. When creative production is technologically "stagnant" but reproduction technology is continually progressing, the commodity as a whole is produced by an asymptotically stagnant production process. The "public good" problem arises where the payment mechanism for the creative activity is dependent on a particular technology of reproduction. And the policy problem is how to trade off the gains of (for example) reduced publishing costs when books are released on disc against the social costs of the fact that authors produce fewer books because no royalties are paid on pirated copies of computer discs.

"Research" may be produced in government departments, publicly funded institutions such as universities or in entirely private sector organizations. The policy issues raised by knowledge production as "research" are therefore on two interacting levels; a) the appropriate level of public finance for research and b) the appropriate institutional locus of production.[5] Governments asked to fund basic research may find themselves tempted by the argument that they could become "free riders," obtaining research results for free which others have paid to produce. National pride, and the argument that one cannot understand or apply leading edge research unless one also produces some of it, may be a deterrent to the 'free rider' strategy. But the fact that the university sector, which is so dependent on government funding, is committed to an ethos of open publication of results - to which all potential competitor nations have free and immediate access - means that university research is almost entirely a "public good" for the international community.

The production of research involves both "knowledge" and "data" workers. The "knowledge" component may be technologically stagnant, in the sense that creative input is always required, but the revolution in information processing technology alters the nature of the production process in research in a more subtle way than simple "asymptotic stagnancy". Research results are now transmitted internationally with far greater rapidity and ease and lower cost than was common even a decade ago – and when we compare the speed with which physicists now communicate internationally and the time it took Newton to receive answers to his correspondence with contemporary researchers, we observe a fairly fundamental change in the technology of research.[6] When knowledge workers are increasing, in aggregate, in the world economy and when researchers obtain almost immediate access to the research results found in any corner of the globe, the result is a very rapid increase in the international division of labour in research, and an exponential rate of growth of research results within narrow sub-specialties. The increasing aggregate volume of research results, and its high level of differentiation, then accentuate the perennial problem of researchers of maintaining contact with relevant literature.

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[4] The verb "to xerox" is commonly used in spoken English, but the property rights to this term are zealously defended by the Xerox Corporation – an example of the difficulties involved in intellectual property rights.

[5] We would underline the fact that public finance of knowledge production does not necessarily imply state sector production – e.g., the Rand Corporation and its government-financed research projects.

It is not much help to a researcher to know that the aggregate volume of scientific research is growing exponentially – a researcher wants access to research results which are *credible* and *relevant* to his own work and has the problem of finding this needle in the global haystack. Assessing the "credibility" of research results is a problem already alluded to in Chapter 3. The typical solution in science is "peer review", as exemplified in the acceptance process of articles in professional journals. But we note that this is typically a non-market solution, since neither authors nor reviewers for scholarly publications are typically paid.

Private sector entrepreneurs have created a solution to the "relevance" problem, one which is dependent on information technology, in the form of computerized data base and reference search firms – as exemplified by the DIALOG service, which sells access to information on where research results are to be found. In this unregulated, private sector industry, the first entrant has an enormous advantage, since the marginal cost of adding a reference to an existing data base is always smaller than the cost of establishing a similar sized data base from scratch. Since reference services have such great "economies of scale", the industrial structure of the reference data base industry is highly unlikely, in the long run, to be a competitive one.[7] The pricing policy of such electronic data base agencies, and the extent to which governments should attempt to regulate such agencies, therefore becomes crucial to the access of individuals to *relevant* research results.

In short, the policy issues raised by the information economy in research are in part traditional and in part novel. The old policy problem of who should pay for public goods, and how, is inevitably accentuated when knowledge production becomes an increasing fraction of economic activity, since decreases in the cost of data transmission accentuate the inherent "public good" characteristic of knowledge. But finding the information needed to solve a specific research problem is a private activity. The newer problem is how to allocate resources to ensuring the credibility and relevance of research output, when research becomes increasingly specialized and international. Assessing the credibility of research largely remains a non-market process, with heavy implicit public subsidies, via the time of professors and other researchers. But, in an increasingly specialized world obtaining information as to where knowledge is to be found becomes increasingly costly – thereby creating a specialized industry, with its own problems of regulation.

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[6] As an example, we note that the initial discovery in 1986 of super-conductive materials was followed within weeks by a surge of international research effort and became, within months, a subject for the general media. By late 1987, hobbyists were experimenting with super-conductive materials.

[7] For example, two firms dominate the industry supplying credit references – Standard and Poor and Dun and Bradstreet.

4.3 International Trade

In the realm of data transmission, the impact of government regulation is highly uneven. Data which is captured on a physical medium, such as a book, tape or computer disk, and which is then physically moved geographically attracts relatively little direct government regulation[8], but this sort of movement can be taxed.. Data captured in a physical medium can be subjected to tariff barriers at national boundaries. Tariff protection is a technically feasible government policy.

Information that moves electronically has traditionally had to use either government owned "post and telecommunication" authorities or highly regulated private utility companies, (although the trend in the U.S. and the U.K. is to deregulated private ownership of such entities). But the point which we wish to emphasize is that information which is moved electronically cannot be taxed on its value at national frontiers – hence *tariffs cannot protect the national origin of knowledge production*. Tariff protection can, and does, imply effective protection to the act of encoding data on physical media, and hence can protect employment in goods-based occupations in industries such as publishing. However, the decreasing cost of electronic information transmission implies that it is increasingly difficult for governments to intervene, via tariffs or other protectionist legislation, to protect the jobs of information workers in national economies.

If, for example, a firm wishes to base its accounting and administration offices in Switzerland while receiving and transmitting data via satellite to and from its plants in Australia, it is not technically feasible to impose an ad valorem tariff on the management services which it is importing from Switzerland. Australia can protect the jobs of its auto workers by placing tariffs on imported cars, but it cannot protect the jobs of its information workers from foreign competition in the same way.[9]

Our basic model implies that the creative activity involved in information production will increase in relative value over time, and that knowledge workers will tend to increase as a percentage of the labour force, but up to now we have applied this model within a national context. The increasing ease of electronic transmission of information implies, however, that one should really think of the global economy as the relevant unit, since information can so easily be transported across national boundaries, and the traditional national methods of protection of employment (such as tariffs) are now increasingly irrelevant. National governments, in a global economy which is increasingly dominated by flows of information, may wish to capture for their citizens a disproportionate share of higher value production – i.e., employment in knowledge based occupations. It is this issue, of the international division of labour in the information economy, to which we hope to turn in further research.

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[8] Artistic and political information is sometimes subject to government censorship, but technical and economic information rarely attracts such attention.

[9] If Australia were to impose very high charges on international telecommunication, or (what amounts to the same thing) provide very low quality service, this would be equivalent to a "per item" tariff, which would protect only the lowest value information jobs – i.e., data workers, not knowledge workers.

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The Information Economy: The Implications of Unbalanced Growth

by
Lars Osberg,
Edward N. Wolff
and William J. Baumol

The majority of Canadian workers today are information workers, concerned with the production, distribution and use of information, versus being directly engaged in the production of goods or "enjoyable" services. Information technology, moreover, is changing the workplace in significant ways, including the occupational structure and skill qualifications of the labour force. Yet these are issues about which we still know relatively little in terms of understanding the changes and their consequences.

The authors of this study attempt to partially remedy this deficiency in current knowledge by analyzing changes in the labour force according to an occupational classification rather than the usual industrial classification scheme. They then go on to examine the determination of individual earnings and the distribution of earnings, with particular reference to the impact of higher education on earnings of so-called knowledge workers and the distributional implications of a growth in low-pay, low-skill "data worker" employment versus a growth in high-pay, high-skill "knowledge worker" employment.

The study concludes with a discussion of three major policy issues arising out of the analysis: educational policy, research and development and international trade issues.

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